POWER PLANT ENGINEERING

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Edgewater Power House in Operation

NEW STATION OF LORAIN COUNTY ELECTRIC CO. SOURCE OF ENERGY SUPPLY FOR NORTH CENTRAL OHIO; COAL AND WATER HANDLING SYSTEMS AND NOVEL METHOD OF RECLAIMING HEAT LOSSES, INTERESTING INSTALLATION FEATURES

REALIZING THE NEED for increased capacity and that higher degree of economy obtainable only by the employment of modern equipment and apparatus, The Utilities Construction Co., a subsidiary of The Lorain County Electric Co., has just placed in operation the first section of a power plant, the ultimate capacity of which is to be 60,000 kw. This new plant, known as the Edgewater Station, is located at Lorain, Ohio, along the south shore of Lake Erie, and for the present will supply electric energy to a system of high-tension lines distributed throughout the north central section of the state. In all, about 55 miles of transmission lines will be served.

While The Utilities Construction Co. was organized primarily for the purpose of building this plant, since construction work was launched this company entered into a contract with the government for a loan of $500,000 and as a consequence it is now found necessary to continue the existence of that construction company. Arrangements have therefore been made to have this corporation operate the plant, The Lorain County Electric Co., however, purchasing all of the energy produced.

The power house is not centrally placed relative to its load, but the location is well suited for the purpose. A continuous and abundant supply of water for boiler feed and condensing purposes is available at all times of the year and, due to excellent rail and water facilities, no trouble ought to be encountered in obtaining the necessary fuel. This, which is delivered over a siding of the

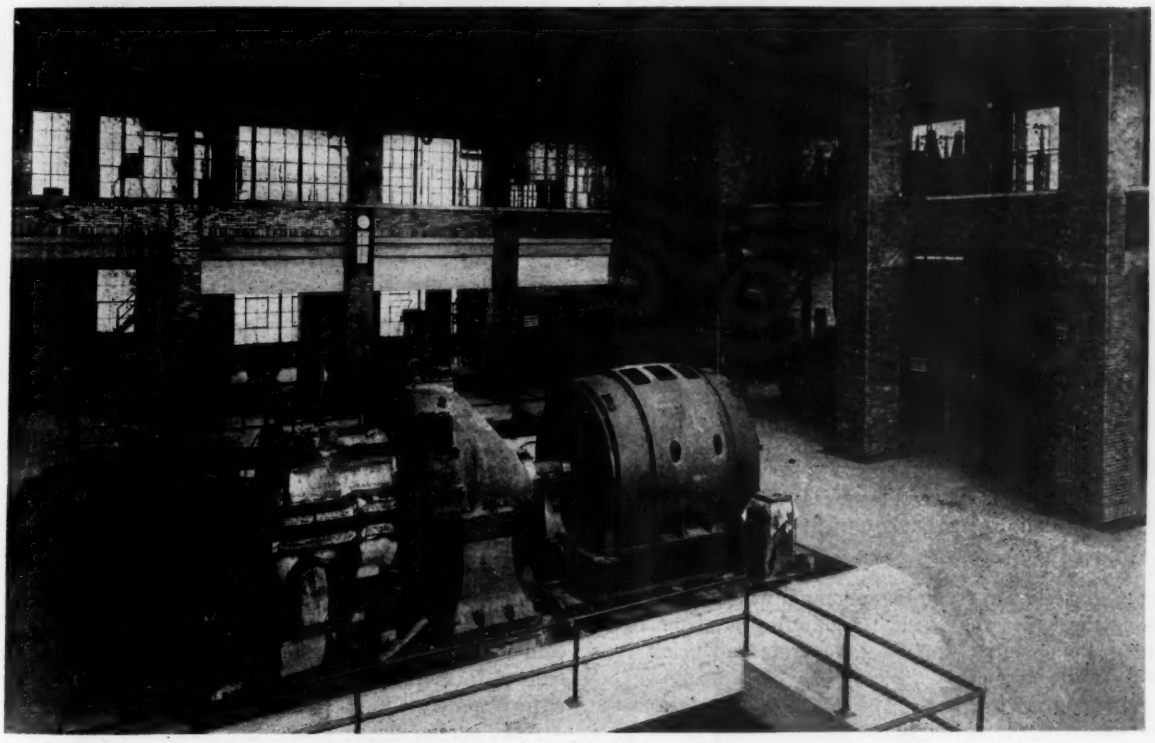


FIG. 4. INTERIOR OF TURBINE ROOM SHOWING SWITCHBOARD GALLERY

Baltimore & Ohio Railway, may be delivered either to the receiving hopper of a conveyor, which, after crushing the coal to the desired size, carries it to the bunkers above the boiler room, or may be dumped from the cars at points beyond the receiving hopper, and distributed over a storage space by means of a locomotive crane, provided for that purpose. The general layout of the coal trestle track and the locomotive crane track is as shown in Fig. 6, which also indicates not only the relative location of the intake channel, the screen house and the discharge tunnel, but also the plan of the present station, and that of the structure as when complete.

That part of the station now erected is, except for the switch house, and the boiler house, a single-story with-basement structure and as may be noted by the plan, Fig. 6, is of L shape, with an overall length of approximately 275 ft. and a maximum width of 127½ ft. Along the boiler room end, the building is about 70 ft. wide. Being entirely of steel, concrete and brick, it is fireproof throughout.

Although of practically the same overall height as the turbine room, the switch house and the boiler house have each been provided with an additional floor, that of the former being above the turbine room floor, while that in the boiler house is placed between the floor of that part of the structure, and the basement. The space so provided is utilized as a pipe gallery for all water and steam lines leading to and coming from the steam generating units and their auxiliaries, and while primarily intended for that purpose with the scheme of arrangement and operation employed, this part of the station will without doubt play a vital part in maintaining a high degree of economy and efficiency.

Air as discharged from the ducts connecting with the generators, is caused to pass into this compartment, where its temperature is materially increased by the radiation of the steam and water piping. It is then delivered to the boiler furnaces at such a temperature as is best suited for the process of combustion, and as a consequence, but little heat of the furnaces is required for preheating purposes.

Practically this compartment is a sealed chamber.

Handling Water and Fuel

Water for boiler feed, condensing, house service and domestic use is taken from Lake Erie through an intake channel 36 ft. in width and 275 ft. long. This terminates in a screen well, which in turn connects with the cold wells in the power house through the medium of a 6 by 6-ft. concrete tunnel having an overall length of approximately 450 ft.

The screen house above the well, although of sufficient size to accommodate four, is at the present time equipped with but two traveling screens, each consisting of 18-in. by 8-ft. screen basket frames to which is attached screen cloth made up of No. 12 galvanized-iron wire having ⅜-in. mesh. The baskets are mounted on two strands of 18-in. pitch chain with steel pins, brass bushings, and cast-iron rollers, ordinarily operating at a rate of 10 ft. per minute. They are each driven by a

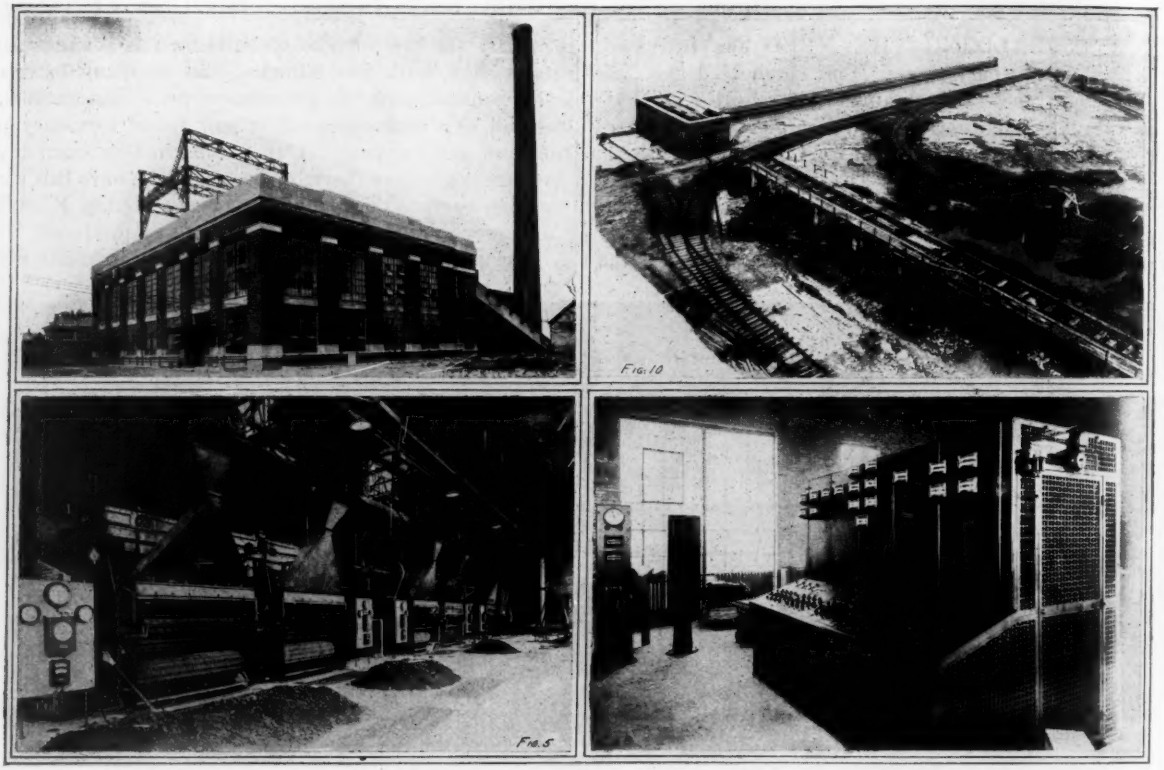


FIG. 1. EXTERIOR VIEW OF EDGEWATER POWER STATION
FIG. 5. INTERIOR OF BOILER ROOM

FIG. 10. SCREEN HOUSE AND PARTIAL VIEW OF COAL RECEIVING AND CONVEYING EQUIPMENT
FIG. 8. CONTROL BOARDS

5-hp. electric motor, the desired rate of screen travel being secured by the employment of suitable reduction gears.

Spraying of the screens is done by means of 2-in. standard pipe, having an overall length of 9 ft. 2 in. and fitted with a 3/64-in. slot. Water and steam for this purpose is delivered to the screen house through 2½ and 2-in. lines respectively, the connections between screen

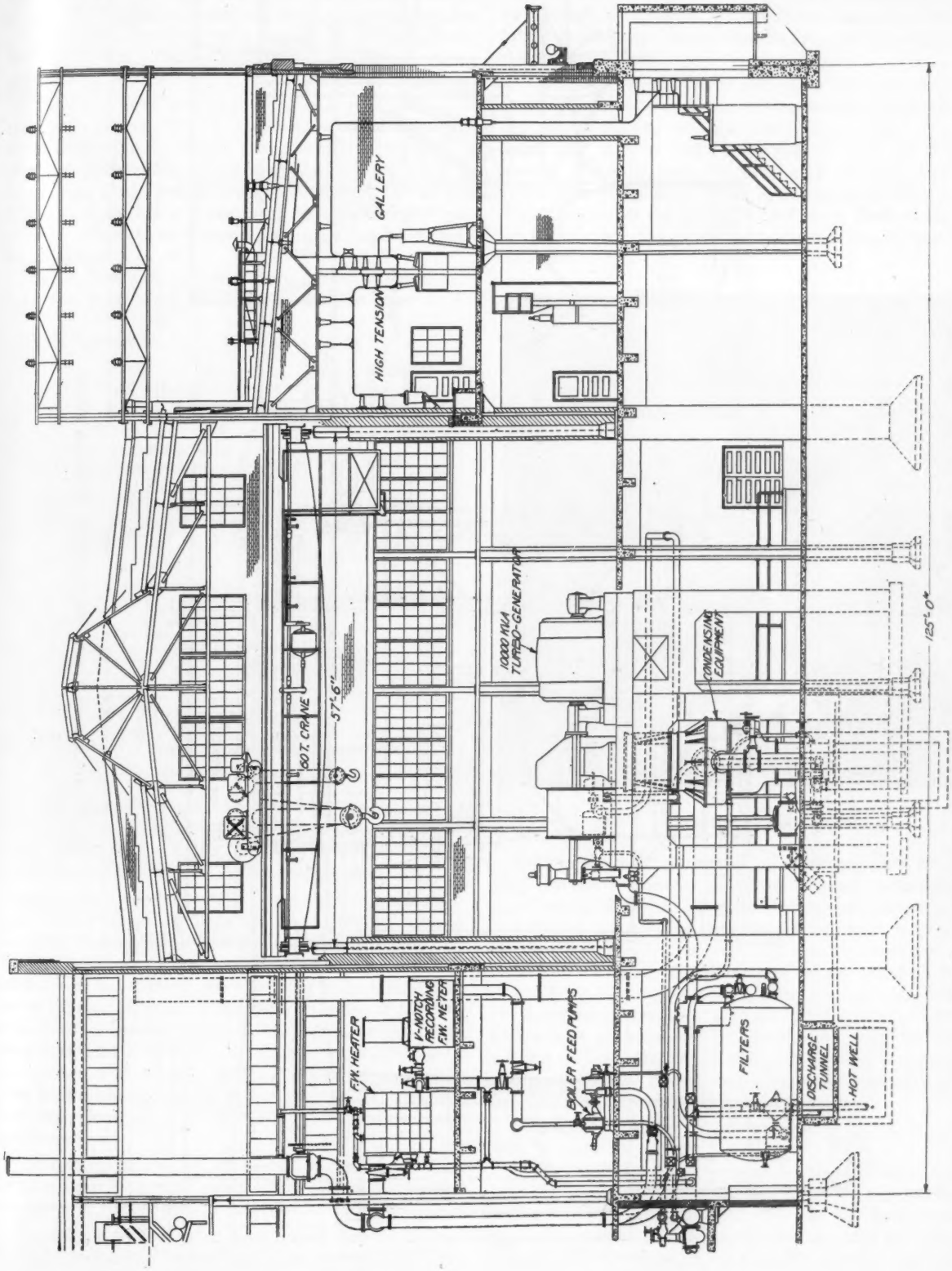


FIG. 2. SECTION THROUGH AUXILIARY GALLERIES, TURBINE ROOM AND SWITCH HOUSE

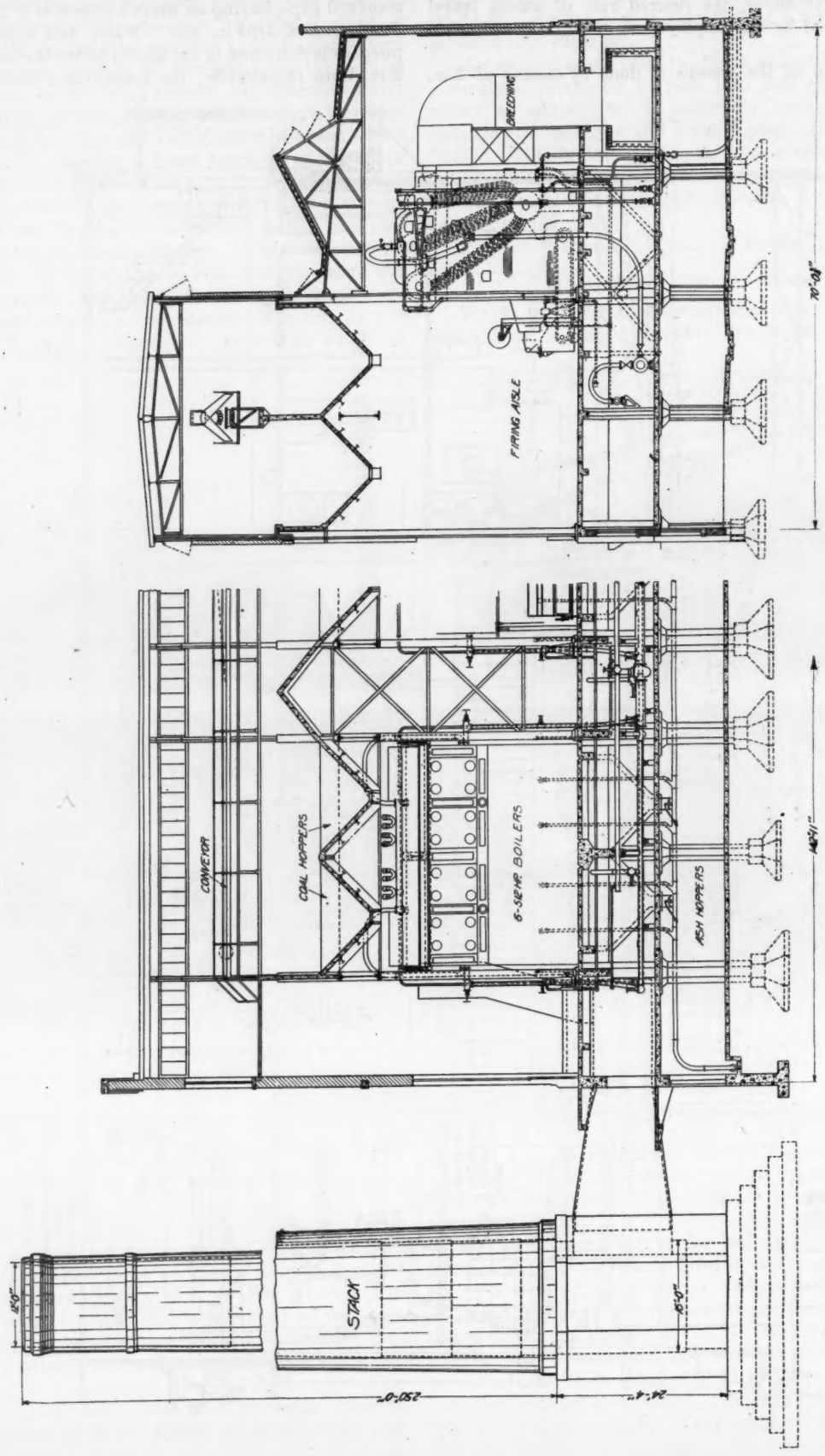


FIG. 3. LONGITUDINAL AND CROSS SECTION OF BOILER HOUSE

house and power house being as indicated in Fig. 6, which also shows in detail the method of anchoring these lines, and the means provided to compensate for expansion and contraction. For the former, located at A, Fig. 6, is a 2-ft. concrete pier, to which are secured the pipes, cast-iron blocks acting as clamps to hold these in place. The expansion bends, of which there are two, are each placed in concrete wells, having an internal diameter of 5 ft. 6 in.; the bends have each a radius of curvature of 2 ft. 3 in.

There are three service pumps, each of which has a rated capacity of 750 gal. per min. Two of these are direct connected to 50-hp. motors and the third to a 50-hp. steam turbine. Water required for plant use is taken from a cold well and pumped through one of two filters, each having a capacity of from 600 to 800 gal. per min. From there it passes through a header supplying the plant.

Boiler feed water is taken from a 2000-gal. steel hotwell tank, located on the boiler mezzanine floor, 10 ft.

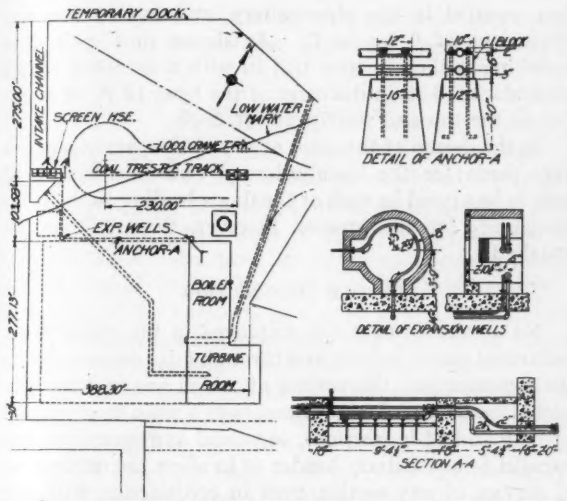


FIG. 6. GENERAL LAYOUT OF STATION AND DETAILS OF SCREEN HOUSE PIPE LINES

above the service pumps. The hot well is supplied by returns from the boiler ledge plates, stokers and water backs; make up is taken from a cold-water header through a 4-in. line, controlled by a copper float valve.

Water from the hot well is pumped to an open feedwater heater rated at 6000 hp. and equipped with a recording V-notch meter having a capacity of 400,000 lb. of water per hour. From here it is fed to the boilers by either one of two 400-gal. per min. four-stage centrifugal pumps capable of working against a pressure of 275 lb., and directly connected to an 85-hp. steam turbine operating at a speed of 2700 r.p.m. These pumps are located directly below the heater and by means of governors maintain a pressure slightly in excess of boiler pressure. Feed water regulators are provided for each steam generating unit.

The service pumps are connected to headers so that any pump can be used to pump either cold or hot water. One pump is always held in reserve.

The cooling water header is connected directly to two 7000-gal. steel surge tanks, located in the south end of the boiler room, and at a height sufficient to give approximately 20 lb. pressure at boiler ledge plates.

The screen house as shown in Fig. 10 is a brick structure having an overall width of over 18 ft., a length of approximately 55 ft. and a height of 17 ft. Through roof hatches provided for that purpose, the screens may be removed by means of a locomotive crane, thus facilitating their ready initial installation and removal for cleaning or repairs.

Cars delivering coal to the plant are run over a double reinforced concrete receiving hopper, below which is a duplex shaking feeder operated by a 15-hp. electric motor and used to deliver the coal to a 30 by 36-in. crusher, which through the medium of an 11-in. belt is driven by a 30-hp. motor running at a speed of 720 r.p.m. From the crusher the coal is carried to the bunkers above the boiler room, the capacity of which is approximately 1025 tons.

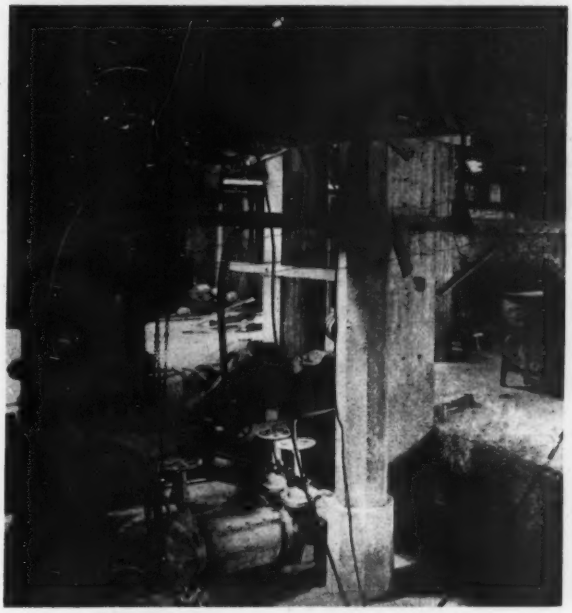


FIG. 7. CONDENSING EQUIPMENT

Due to the arrangement of plant employed, a somewhat extensive conveying system became necessary. Upon leaving the rolls of the crusher, the coal is deposited in a pocket from where it is distributed upon a 20-in. 4-ply rubber-covered duck belt and carried a distance of about 260 ft. to a cross conveyor, at an elevation of about 77 ft. above the crusher discharge spout. The belt which ordinarily travels at a speed of 315 ft. per minute is driven by a 15-hp. electric motor and except for the two end pulleys spaced with 270½-ft. centers, is carried by sixty-one 20-in. troughing pulleys and twenty-six return rollers of like width.

The rated capacity of this conveyor is 100 tons per hour.

Conveyor B, that used to transfer the coal from the elevating conveyor to the one employed to supply the bunker, also has a capacity of 100 tons per hour, and operates at a speed of 315 ft. per minute. It is made up of 4-ply rubber-covered 28-oz. duck 20 in. wide, with an

overall length of 136 ft. and a lift of approvimately 13 ft. and is supported by sixteen 20-in. troughing idlers and five 20-in. return idlers. The motor used for its operation has a rated capacity of 7½ hp.

Carried centrally along the tops of the bunkers and carrying an automatic tripper and distributor provided with double discharge spouts so as to insure a uniform distribution of the coal is conveyor C. This, which has the same rated capacity and is operated at the same speed as the elevating conveyor and cross conveyor B, is made up of 4-ply rubber-covered 26-oz. duck and except for the two end pulleys is carried by 29 troughing and 10 return idlers, each with a width of 20 in.

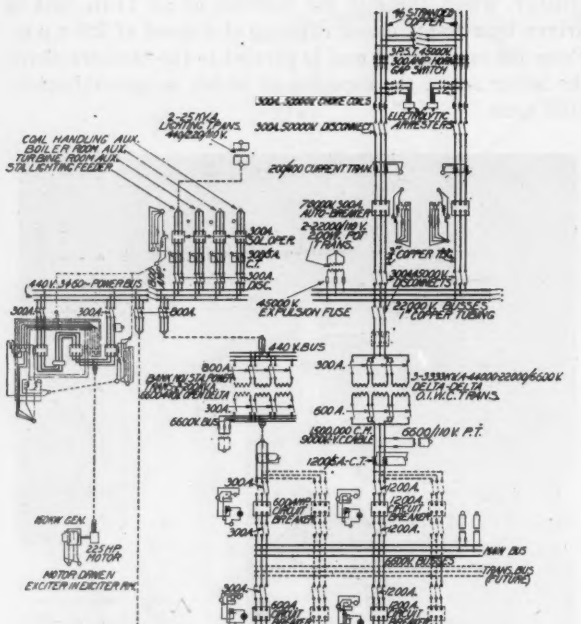


FIG. 9. DIAGRAM OF CONNECTIONS OF ELECTRICAL SYSTEM

A 7½-hp. electric motor, in conjunction with suitable reduction gearing is employed to operate this conveyor.

Construction of the coal bunker in the boiler room provides a hopper for each unit. Below each hopper is located a beam scale, of the registering type, having a capacity of five tons, which is directly connected to the boiler spout. This arrangement provides a record of coal burned in each boiler. A platform is hung from the hoppers and runs the length of the boiler room, making the scales readily accessible to the operators.

The Boilers

In the boiler room proper is an installation of six water-tube boilers of the form shown in Fig. 3 and arranged in three batteries of two units each. These boilers, which are equipped with superheaters and chain-grate stokers 11 by 13 ft., and having active grate surfaces of 143 sq. ft., are rated at 512 hp. and designed to carry steam at 200 lb. pressure. Ordinarily 100 deg. F. superheat is employed.

The furnaces, which have both ignition and ventilating arches, spanning the entire width, are fitted with water-cooled ledge plates, and vertical pressure backs, and at the rear are supported by water-cooled girders to eliminate the possibility of overheating and consequent sagging of the grates.

Built integral with the structure and directly below the boiler settings are reinforced concrete hoppers, that at the rear for ashes and soot, while that toward the front of the boiler is for the collection of green or partially burned coal, which may find its way through the grates.

Each battery of boilers is fitted with its individual insulated sheet-iron breeching, having overall dimensions of 5 ft. 4 in. by 9 ft. 4 in. and made up of 3/16-in. plates, reinforced by means of 2½ by 2 by 3/16-in. angle irons. These connect in turn, through the medium of ducts built up of the same material and of like dimensions, with a main masonry breeching, carried below the boiler room floor parallel to the pipe gallery, and having internal dimensions of 6 by 12 ft. As shown in Fig. 3, this breeching is then in turn tied in with a detached radial brick stack, 16 ft. in diameter at the base, 12 ft. in diameter at the top and nearly 275 ft. high.

In the design of this part of the station, arrangements were made for the installation of economizers, one of each to be placed in each of the ducts leading to the main breeching; for the present, however, these will not be installed.

Steam Distribution

No overhead piping is employed in the boiler room. Saturated steam is delivered through 6-in. goose necks, to the superheaters, the outlets of which are in turn connected by means of 6-in. branches to a main header made up of 6 and 14-in. sections, so valved and connected to a parallel 6-in. auxiliary header as to allow the cutting out of service of any section used in conjunction with any one of the batteries. Steam to the turbine is supplied through a 12-in. line equipped with a separator.

In addition to the regulation shutoff valve, each boiler outlet is fitted with a non-return valve.

Auxiliaries such as some of the pumps and the turbine-driven exciter, ordinarily take their supply through branches connecting with the 6-in. auxiliary header.

Steam exhausted from the various auxiliaries discharges into a riser tied in as shown in Fig. 3 with the feed-water heater, the arrangement employed being such as to allow all excess steam to pass out to the atmosphere through a 20-in. line fitted with a back pressure valve and provided for that purpose. A separate atmospheric relief line 30 in. in diameter is used in conjunction with the condenser on the main turbine.

Main Generating Equipment

At present this will consist, as shown in Figs. 2 and 4, of but a single unit, a 10,000-kv.a. (8000 kw.) three-phase, 60-cycle 6600-v. turbo-generator set with the steam end, a combination impulse-reaction turbine built on the single-flow principle and designed for operation with steam at 180 lb. pressure, 100 deg. F. superheat and a vacuum of approximately 28½ in.

The condenser used in conjunction with this unit and located in the turbine room basement is of the Leblanc low-level jet type. It has a capacity of 5,000,000 lb. of cooling water per hour and is capable of condensing 140,000 lb. of steam each hour, with the injection water at a temperature of 70 deg. F. Air and circulating water pump runners are mounted on a common shaft driven through the medium of a 7 to 1 reduction gear by means of a 286-hp. steam turbine operating at a speed of 3500 r.p.m.

The air pump is of the Leblanc hurling type and is bolted to the side of the condenser.

In the exciter room adjoining the turbine room, place has been provided for four exciter units. Up to the present, however, but two of these, one a 150-kw. motor-generator set and the other a steam turbine operated unit with a rated capacity of 100 kw., have been installed.

Each of the exciters delivers current at a voltage of 250 to bus bars mounted at the rear of a separate three-panel board carrying the usual complement of instruments, regulators and switches for the control of the current flow to the field windings of the main generator. The scheme of connections employed is as shown in Fig. 9.

Electrical Layout

Until more generating units are installed, but a single set of 6600-v. busses will be employed. Current from the generator is carried to these by leads which also connect directly with a bank of three 3333-kv.a., 6600 to 22,000-44,000-v. delta-delta connected water-cooled transformers placed in the basement of the turbine room. Each side of the busses is protected by a 1200-amp. oil circuit breaker, the incoming and outgoing legs of which are fitted with disconnect switches of like capacity.

After being stepped up to 22,000 v., the current is further delivered to a set of 22,000-v. busses made up of 1-in. copper tubing, to which, as shown, are connected two sets of outgoing leads each carrying the necessary disconnect switches, and a 70,000-v., 300-amp. automatic circuit breaker, 300 amp., 50,000 v., choke coils and electrolytic lightning arresters with sphere horn gap. These leads, like the busses to which they are connected, are also of copper tubing, but ¾ in. in diameter; three single-throw 300-amp., 45,000-v. horn gap switches mounted on the roof of the switch house allow the use of either set for the feeding of the high-tension transmission lines, thus insuring continuity of service, between the 22,000-v. busses and the outside circuits.

Beyond the 66,000-v. roof bushings, through which the leads pass, 4/0 stranded copper is employed.

Two banks of transformers, each made up of two 200-kv.a. 6600 to 440-v. units connected in open delta, are installed for station light and power service. This portion of the equipment is in duplicate, with leads each carrying a 600-amp. oil circuit breaker and two 300-amp. disconnect switches terminating in individual 6600-v. busses to which, through the medium of 300-amp. disconnect switches, the transformer primary windings are connected. The secondaries through 800 amp. disconnect switches feed 440-v. busses, which in turn feed 440-v. split distributing busses, the two sections being separated by means of 800-amp. disconnect switches.

One section of this bus supplies current exclusively to the motor-driven exciter set while the other through branch distribution circuits serves the coal-handling auxiliaries, boiler room auxiliaries, turbine room auxiliaries, and the station lighting feeder, which connects with a bank of two 25-kv.a., 440 to 220-110-v. transformers. Three hundred ampere disconnect switches and solenoid circuit breakers of like capacity are provided for each of these distribution circuits.

The diagram, Fig. 9, indicates not only the present scheme of connections, but also the arrangement it is planned ultimately to employ. An additional or so-called transmission bus will be used with independent leads to the generators, the step-up transformers and each of the station service transformers, thereby enabling the serving of either the transmission lines or the station transformers by either one of the sets of busses, or, if so desired or required, one set of busses may be used to feed the transmission lines with the other, the station service transformers.

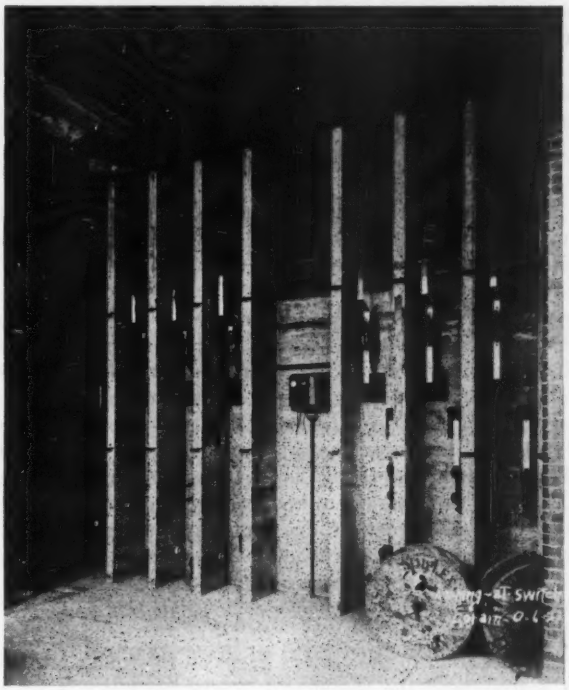


FIG. 11. TYPICAL SWITCH BARRIERS

High-voltage and station transformers are placed in the basement of the switch house, exciters and low-tension bus structures on the floor of the turbine room, while the control board, the station power board, instrument and regulator pedestals and battery-charging motor generator set are found in the control room, a gallery built over the turbine room floor.

For emergency lighting and the operation of oil switches a 125-v., 96-cell A6H. Edison nickel-steel alkaline storage battery is installed. The motor-generator set used for the charging of this battery is a 10-kw., 125-v. unit and as stated above is located in the control room.

Generator Air Conditioning Equipment

Installed in the basement of the turbine room is a

complete air washing and humidifying equipment, having a capacity of 32,000 cu. ft. per minute, at a velocity of 550 ft. per minute, and capable of removing 98 per cent of the dirt contained in the air going to the generator. This is carried to the machine through a short sheet-metal connection, and after being passed through the windings is delivered to the chamber below the boiler room by means of a duct having a sectional area of 32 sq. ft.

The washer proper, which has a width of 10 ft. 7½ in., a height of 7 ft. 1½ in. and a length somewhat in excess of 7 ft., is built up of 18-gage galvanized iron braced on the outside with 1½ by 1½-in. galvanized steel angles. It is provided with 80 spray nozzles and 41 flooding nozzles and with a washing surface exclusive of eliminating surface of 553 sq. ft.

Water is supplied by means of a single-stage centrifugal pump, having a rated capacity of 329 gal. per min. and driven by a direct-connected 10-hp. electric motor.

Instruments

Each boiler is equipped with a gage board, located just to the side of the stoker so that all the instruments are immediately in view of the fireman. On this board have been placed meters showing the steam flow in pounds per hour, the air flow through the boiler, and the temperature of the flue gases, a 2-pen recording gage showing the steam pressure entering and leaving the superheater, a recording thermometer showing the temperature of superheated steam leaving the boiler, and a 2 in 1 draft indicator, showing the draft over the fire and that in last pass. Space has been left for installing a CO_2 recording instrument and two 2-pen recorders showing the temperature of flue gases and temperature of water entering and leaving the economizers. Control of the boiler damper will also be operated from this board. An 18-in. master steam gage will be located at one end of the boiler room.

In addition to the various gages on the turbine, there is placed near the steam end of the generator a gage board, on which are the following instruments: A steam flow meter, showing flow of steam to turbine in pounds per hour; a recording pressure gage; a 3-pen recorder showing the temperature of the exhaust steam, the temperature of water entering and that leaving the condenser; also a barometer and mercury column.

Recording instruments placed in the pump room also show the temperature of the water entering and leaving the feed water heater. Wherever a recording instrument is placed there is also provided an indicating instrument, thus giving a continuous check on the former.

Personnel of Construction Organization

Building features as well as the general design of the structures were worked out by the engineers of The A. Bentley & Sons Co., of Toledo, Ohio, who were retained by The Utilities Construction Co. in an advisory capacity for this work. All mechanical engineering was in charge of J. B. Johnson, general manager of The Lorain County Electric Co., assisted, up to the time of his death last December, by M. C. Conley. H. H. Wonning succeeded Mr. Conley as mechanical engineer and has since been in active charge of this phase of the work.

The Superheating Effect of a Reducing Valve

By N. H. Hunt

I RECENTLY carried out a test to determine the superheating effect of a reducing valve placed in a 10-in. pipe line from a battery of Lancashire boilers. The reducing valve was lagged and fitted with the usual traps, the steam was supposed to be almost dry. The steam flow was 30,000 lb. per hr. when the observations were made.

The mean of 12 readings gave:

Pressure before valve, 143 lb. per sq. in. gage.

Temperature before valve, 362.5 deg. F.

Pressure after valve, 90 lb. per sq. in. gage.

Temperature after valve, 331 deg. F.

The temperatures corresponding to the pressures from the tables are 362.2 deg. and 331 Deg. F., respectively, showing that there was no superheating effect. Reference to the Mollier diagram shows that the steam should have been superheated 10 deg. F. after it had passed reducing valve if the steam was dry saturated at higher pressure. The steam in expanding must therefore have given up the difference of its total heats at the respective pressures to evaporating water present at the higher pressure.

The difference in the total heat per pound = 1192.4 — 1182.9.

At the two pressures = 9.5 B.t.u. per lb.

For each pound of steam flowing, therefore, 9.5 B.t.u. were available for evaporation.

The sensible heat is lower at the smaller pressure by 330 — 299 = 31 B.t.u., 330 and 299 being the heat units required to raise the temperature of each pound of water from 32 deg. F. to the temperature at which it exists as steam. The amount of heat required to evaporate 1 lb. of water at the higher temperature will therefore be the latent heat per pound at the lower pressure minus 31, or 881 — 31 = 850 B.t.u. per pound.

During the above test, therefore, for each pound of steam passing the valve $\frac{9.5}{850}$ lb. of water at least must have been present, i.e., 1.12 per cent. It was impossible to vary the weight of steam passing the valve or to measure the actual wetness of the steam.

Engineering.

We have been wont to look upon concrete as capable of resisting a great deal of heat, and it may seem strange to think of coating it with a fireproof material. However, there are conditions under which this is necessary. The Bureau of Standards has been investigating the condition of concrete which has passed through conflagrations, and has found that if the concrete is made with gravel, particularly siliceous gravel, there is a tendency for the stones to burst in extreme heat, which disintegrates the concrete. Accordingly, it is recommended that gravel be avoided wherever possible, but if impossible, the gravel concrete may be protected from extreme heat by coating it with an inch of cement held in place by a wire mesh. Plasters may also be used in which asbestos is the principal constituent.

—Scientific American.

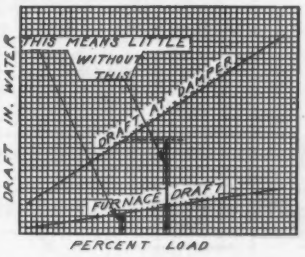
FUEL CONSERVATION LETTERS

By Joseph Harrington, Formerly Administrative Engineer for the State of Illinois

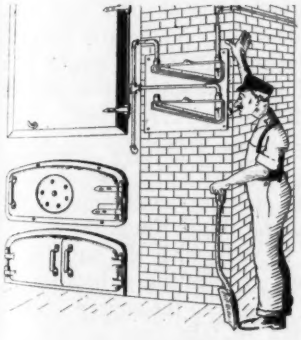
Draft and Its Significance. Letter No. 16

THE WORD "draft" is probably the most used expression in the boiler room and it is quite as likely that it is about as little understood as any. It is really used in a double sense; that is for the energy or force which causes the movement of air into and through the furnace, and also for the air itself.

The latter use of the word is improper. Draft is really a measure of the pressure of the gas in a certain location. Increase in this pressure does not indicate an increased amount of air flowing past the fuel bed or boiler unless certain other conditions are determined. As a matter of fact, in the case of a fuel bed, the reverse is frequently the case. A high furnace draft more often than otherwise indicates a high fuel bed resistance, and consequently a decreased flow of air. With a given draft at the boiler damper, this may be considered a positive statement and the furnace draft therefore becomes a measure of the fuel bed resistance and inversely a measure of the rate of air flow. Too often do we find men in the boiler room who, because they happen to find a high draft in the furnace, think that this means excellent conditions in the setting and a high capacity. Do not let yourself be fooled in any such manner. A proper interpretation of furnace draft can only be had when the draft in the damper is known; from which information can be determined the draft loss or drop of pressure in the boiler itself.



For all practical purposes, the boiler may be considered an orifice of fixed dimensions. Unless the baffles develop leaks or the heating surface becomes heavily coated with soot, this is a correct assumption. The amount of draft loss in the boiler becomes, therefore, a measure of the resistance offered to the flow of gases; and this resistance is in turn the measure of the volume of gases passing through the boiler. Now, this indication would be secured if the gas flowing through the boiler were pure air, so that the draft loss in the boiler indicates only the volume of the furnace gases and nothing as to their quality; however, a very fair approximation of quality can be made by noting also the furnace draft or fuel bed resistance. To check this indication against quality, gas analyses should be made, observing the furnace draft and the loss through the boiler. It will be found that a certain fuel bed resistance (assuming a uniform size of coal) corresponds to a certain gas analysis. As the fuel bed is thickened, the resistance increases and the amount of air passing through the fuel bed is decreased, which results in less air per pound of fuel burned, or an increase in the CO_2 content of the flowing gases. If a hole should develop in the fire, the fuel bed resistance would be lessened, more air would flow into the furnace, and the CO_2 would drop. At the same time, as the latter occurrence takes place, there would be an increased friction loss in the boiler due to the larger gas volume and the draft loss would show up greater.



These two conditions, therefore, studied in conjunction, indicate approximately the changes in the efficiency conditions of the fire and with any given plant using about the same grade of coal, they offer a very fair indication of fluctuations in furnace efficiency.

The draft gage being such a simple instrument, not requiring any special upkeep or attention, becomes, therefore, a most practical device for the boiler room which cannot afford the more expensive and elaborate equipment of gas analyzers and recording gages. Certainly, no boiler room should be without its complement of draft gages and the engineer can, by the use of a hand-analyzer for a week or two, establish certain fundamental relations between the fuel bed resistance, boiler resistance, and CO_2, which will serve as a very satisfactory guide to his fireman.

Needless to say, the draft gages referred to should be placed in a position very easily discernible by the man charged with the firing. The superintendent or owner, as he makes his occasional rounds, can at a glance determine the condition of the fire.

The Bleeder Turbine

Its Use, Design and Construction. By Josef Y. Dahlstrand.

THE bleeder or extraction turbine has in the most satisfactory way solved the problem of heat balance in the average small and moderate size power plant.

The operation in any steam power plant, if considered from the standpoint of potential qualities in steam, may be divided into two stages. The first, or high-pressure, stage is that in which the heat energy in the steam available between boiler pressure and heater pressure (atmospheric or slightly higher) is converted into

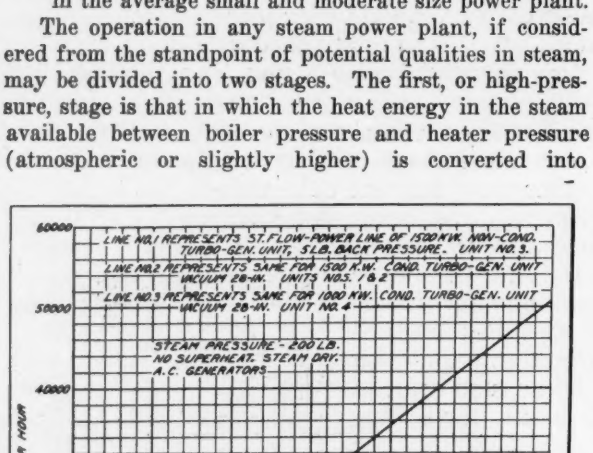

LINE NO.1 REPRESENTS ST. FLOW-POWER LINE OF 1500 KW. NON-COND. TURBO-GEN. UNIT, 51 LB. BACK PRESSURE. UNIT NO. 3.
LINE NO.2 REPRESENTS SAME FOR 1500 K.W. COND. TURBO-GEN. UNIT VACUUM 28-IN. UNITS NOS. 1 & 2
LINE NO.3 REPRESENTS SAME FOR 1000 KW. COND. TURBO-GEN. UNIT VACUUM 28-IN. UNIT NO. 4
STEAM PRESSURE - 200 LB. NO SUPERHEAT. STEAM DRY. A.C. GENERATORS
TOTAL STEAM PER HOUR
LINE NO.1
LINE NO.2
LINE NO.3
LINE NO.2A
LOAD IN KILOWATTS
FIG. 1
KILOWATT LOAD
L.P. STM. DEMAND RATE IN LBS. PER HR.
LOAD KW.
STEAM L.P.
MIDNIGHT
NOON
MIDNIGHT
FIG. 2

FIG. 1. STEAM FLOW-POWER LINES OF INDIVIDUAL UNITS
FIG. 2. PLANT LOAD CURVE FOR 24-HR.

mechanical work. The second, or low-pressure, stage is that in which the heat energy available for conversion in the steam at heater pressure is changed to mechanical work or dissipated by heaters, radiators, etc.

The heat energy in the first stage of conversion is almost exclusively expended to obtain power. Sometimes this process of energy conversion is interrupted at atmospheric pressure—in which case the power motors, turbines or engines are said to operate noncondensing. In other cases it is continued below atmospheric pressure to a vacuum, in which cases the second stage of operation or low pressure is carried through and the power motors are said to run condensing.

Uses for Energy in Low Pressure Steam

Considering further the second stage of conversion of energy, the low-pressure steam, in addition to being required at times to furnish power, is used for a great many purposes. These are, briefly, as follows:

1. Heating of Building. Steam heat is found superior to water in the case of factory buildings where the heating medium must be carried a considerable distance and often above the point of supply. Steam heating also generally proves the most economical for this purpose.

2. Heating of Feed Water for Boilers. Heating of feed water by the use of exhaust steam has proven to be very desirable. Not only will this give a decided fuel saving but it will also increase the steaming capacity of the boilers in that for a certain heat transfer from the fuel to the water, as each pound of water will require a lower number of heat units to be evaporated, a greater quantity of water may be evaporated with a certain quantity of fuel.

3. For Manufacturing Purposes. Such are—process work in connection with paper manufacture, drying of lumber, bleaching and drying in textile mills, heating of retorts in sugar refineries. In addition, exhaust steam is used in chemical plants for a great number of purposes furthering different reactions.

The steam used for these purposes is generally taken from the exhaust of a noncondensing engine or turbine.

The auxiliaries in a power plant are generally operated noncondensing to render them independent of the main units and the condensing equipment, which is usually necessary for starting of the main unit. The exhaust steam from the auxiliaries is generally used for heating of the boiler feed water.

The supply of low-pressure steam in a power plant, if all its power units are operating condensing, is practically constant, as the load of the auxiliaries, and hence their steam consumption, does not vary greatly with the load of the plant. If, however, part of the power units are operating noncondensing, the supply of low-pressure steam will increase with increased power output.

The demand for low-pressure steam for heating of feed water might always vary with the load, and the demand for other purposes may vary with time of day, with seasons, etc. As a general thing, hence, the demand has no natural tendency to vary with the supply. If there were no other means of effecting a balance, the natural thing to do would be to keep the supply of steam at a point sufficiently high to take care of the peak demand and at all other times when a smaller amount of steam was required, if supply remained unchanged, the balance of the steam had to be wasted. This is also what actually takes place in a great number of small and medium size plants.

Balancing Supply and Demand

The problem of balancing the supply and demand of steam with power output is solved in a great number of ways. The merits of these ways vary with several circumstances, such as size of plant—whether one or many power units—and the true merits of any one way must, of course, be on the basis of dollars and cents, and take in not only economy of operation, but cost of installation, interest charges, etc.

When a minimum demand for low-pressure steam is adequately taken care of by noncondensing operating auxiliaries for the main turbines or engines, some of these latter units may be designed to give full load running either noncondensing or condensing and to be operated noncondensing when there is a maximum demand for low-pressure steam. Turbines built for this kind of operation are common at the present time. Generally noncondensing operation in a turbine of this kind is less economical than it would be were the same turbine designed for noncondensing operation only. Economy of operation is, in this case, however, not necessarily of major importance, as part of the energy wasted through the inefficient operation of the steam turbine will be regained in heating later.

The disadvantage of this type of installation, in case there are only one or two main turbines, lies in the fact that each turbine must exhaust all its steam either to heating system or else to the condenser, hence becomes uneconomical when the demand for low-pressure steam from the main turbines does not coincide with the supply of exhaust steam from the unit operating noncondensing with the particular load this turbine carries.

Another arrangement is to have a sufficient number of turbines running noncondensing to take care of the peak demand for low-pressure steam outside of the boiler plant, and at other times exhaust the surplus of low-pressure steam to feed-water heater. It is likely, however, that in many cases the amount of exhaust steam thus available for use in heating the feed water would be more than could actually be used.

A third solution would be to use a low-pressure turbine to consume the excess of low-pressure steam available at times other than the peak demand for low-pressure steam for heating. In this case, whenever this peak was experienced, the low-pressure turbine could not be operated or would have to operate at partial load. As a consequence, the low-pressure turbine would have to be a spare machine, or at least there must be a sufficient number of other machines to take care of the difference between the maximum and minimum load of this low-pressure turbine. This might in some cases prove to be burdensome, and for this reason the fourth alternative, a mixed-pressure turbine, has been developed.

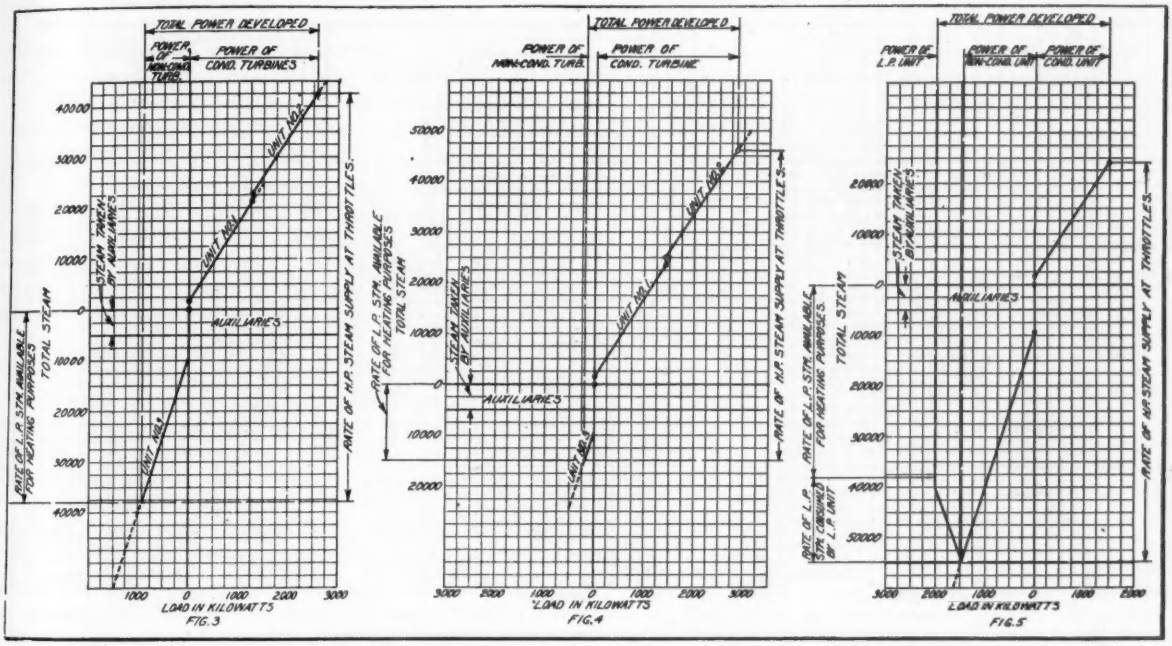

TOTAL POWER DEVELOPED
POWER OF NONCOND. TURB.
POWER OF COND. TURBINES
UNIT LOAD
AUXILIARIES
STEAM TAKEN BY AUXILIARIES
RATE OF L.P. STM. AVAILABLE FOR HEATING PURPOSES
TOTAL STEAM
RATE OF H.P. STEAM SUPPLY AT THROTTLES
LOAD IN KILOWATTS
FIG. 3
POWER OF NON-COND. TURB.
POWER OF COND. TURBINE
RATE OF L.P. STM. AVAILABLE FOR HEATING PURPOSES TOTAL STEAM
FIG. 4
POWER OF L.P. UNIT
POWER OF NON-COND. UNIT
POWER OF COND. UNIT
RATE OF L.P. STM. CONSUMED BY L.P. UNIT
FIG. 5

FIG. 3. MOMENTARY PERFORMANCE CONDITIONS OF PLANT AT 3:50 P. M.
FIG. 4. MOMENTARY PERFORMANCE CONDITIONS OF PLANT AT 5:10 P. M.
FIG. 5. MOMENTARY PERFORMANCE CONDITIONS AT 3:50 P. M. IF LOW-PRESSURE TURBINE IS USED

The mixed-pressure turbine gives more flexibility to the operation in the power plant, as it may be operated on low-pressure or high-pressure steam condensing. Some makes of mixed-pressure turbines will even give full load noncondensing, but this generally with an inferior steam economy.

A Typical Example

To illustrate properly the application of the bleeder turbine to the power plant and the advantages derived through the use of this type of machine over others, the operation in a relatively small power station in connection with a chemical plant will be considered.

This power plant has a load which fluctuates greatly and a demand for low-pressure steam which also suffers wide changes. The maximum load is 3500 kw. The maximum total amount of low-pressure steam required

is at the rate of 38,000 lb. per hour. The steam pressure is 200 lb. dry and saturated. The heater pressure is 5 lb. gage. The vacuum is 28 in.

The station has two 1500-kw. units and one 1000-kw. unit operating condensing; also one 1500-kw. unit operating noncondensing exhausting into heating system. All auxiliaries also operate noncondensing and exhaust to heating systems.

The operation in a power plant may well be illustrated by a so-called "steam flow-power line." This line illustrates the relation between the total steam input in pounds per hour to the actual kilowatt output. This line may be plotted for individual power units or for an entire power plant. In the former case it approaches a straight line, while in the latter it generally has bends and breaks and offsets.

of the larger turbine is better than that of the smaller —as might be expected.

It might be stated at this point that the actual total steam power lines for these units vary somewhat from those shown.

All these machines are so designed that they will automatically carry a certain amount of overload. Also, due to the bettered vacuum for low loads when the condenser capacity is large in proportion to the amount of steam condensed, considerably more power will be developed at partial loads than the curves indicate. Line No. 2A shows approximately the results obtained with the 1500-kw. units.

Figure 2 shows the performance of the plant for 24 hr. with a line for load and another for low pressure steam demand plotted against time of day.

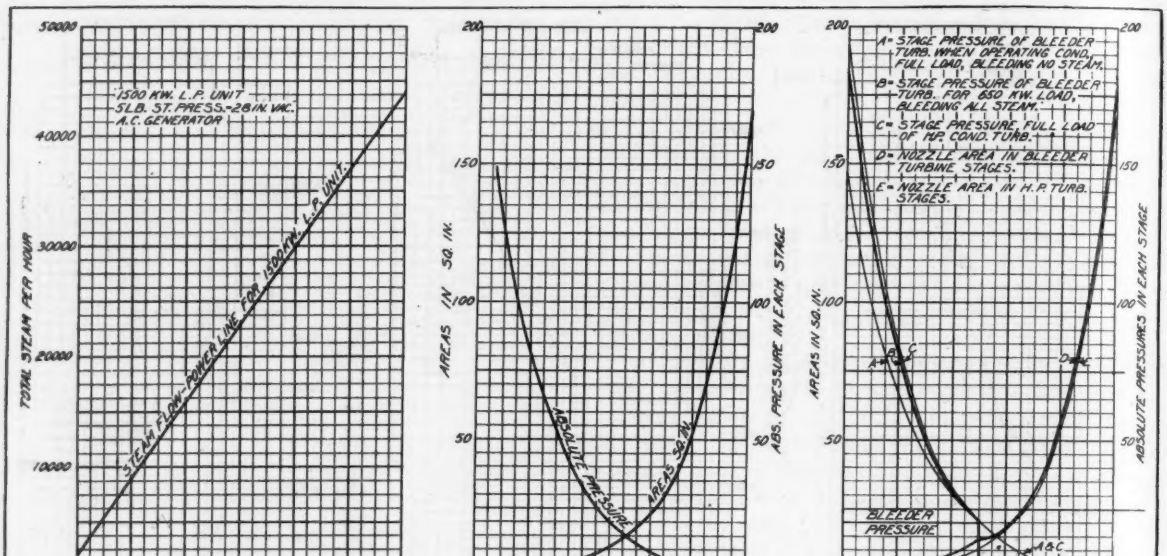

1500 KW. L.P. UNIT
5 LB. ST. PRESS.-28 IN. VAC.
A.C. GENERATOR
STEAM FLOW-POWER LINE FOR 1500 KW. L.P. UNIT
TOTAL STEAM PER HOUR
LOAD IN KILOWATTS
FIG. 6
AREAS IN SQ. IN.
ABS. PRESSURE IN EACH STAGE
ABSOLUTE PRESSURE
AREAS SQ. IN.
STAGES
FIG. 7
A = STAGE PRESSURE OF BLEEDER TURB. WHEN OPERATING COND., FULL LOAD, BLEEDING NO STEAM.
B = STAGE PRESSURE OF BLEEDER TURB. FOR 650 KW. LOAD, BLEEDING ALL STEAM.
C = STAGE PRESSURE, FULL LOAD OF H.P. COND. TURB.
D = NOZZLE AREA IN BLEEDER TURBINE STAGES.
E = NOZZLE AREA IN H.P. TURB. STAGES.
AREAS IN SQ. IN.
ABSOLUTE PRESSURE IN EACH STAGE
BLEEDER PRESSURE
STAGES
FIG. 8

FIG. 6. STEAM FLOW-POWER LINE FOR 1500-KW. LOW-PRESSURE UNIT

FIG. 7. RELATIONS BETWEEN STAGES, AREAS OF NOZZLES AND ABSOLUTE PRESSURES OF HIGH-PRESSURE CONDENSING TURBINES

FIG. 8. RELATIONS BETWEEN STAGES, AREAS OF NOZZLES AND ABSOLUTE PRESSURES OF A BLEEDER TURBINE

In Fig. 1, steam flow-power lines have been drawn for the individual units installed in the above mentioned power plant. Observing Line No. 1, it will be seen that at 1500 kw. this unit requires 50,800 lb. of steam, which corresponds to a steam rate of 33.9 lb. per kw.-hr. Lines Nos. 2 and 3 show performances of condensing machines. At full load the 1500-kw. units require 24,400 lb. of steam and the 1000-kw. units require 16,500 lb.—representing steam rates of 16.2 and 16.5 lb. per kw.-hr. respectively. A condition worthy of notice is the fact that Line No. 3 lies below Line No. 2, i.e., for a certain steam flow at the throttle the 1000-kw. unit is more economical than the 1500-kw. unit. This, as will readily be understood, is due to the fact that a certain steam flow in the larger unit corresponds to a lower partial rating of same unit than the same amount of steam in relation to the smaller unit. On the other hand, the full load performance

Naturally, only relatively coarse fluctuations can be recorded. As a matter of fact, in a number of stations such, for instance, as chemical plants, both the rate of steam demand and power suffer violent momentary fluctuations.

A diagram of desired momentary conditions can, of course, be produced for every moment of operation. The writer has found that illustrated in Fig. 3 a convenient form of such a diagram. This shows performances at 3:50 p. m. On this are recorded total steam in a vertical direction, in a similar manner to Fig. 1, and power is recorded in a horizontal direction. The performance of the condensing units is illustrated in the first quadrant and that of the noncondensing unit in the third quadrant. The consumption of steam taken by the auxiliaries is assumed constant.

As will be noted, the total output is 3500 kw., of which No. 1 and No. 2—1500 kw. condensing units each

furnish about 1290 kw., and No. 3 unit—1500 kw. noncondensing unit, furnishes 920 kw. The total steam flow from the boilers is at the rate of 80,500 lb. per hour. The low-pressure exhaust steam available from auxiliaries and No. 3 unit is at the rate of 38,000 lb. per hour.

It will be evident from the diagrams that steam flow-power lines in Fig. 3 are arrived at by interposing lines illustrated in Fig. 1 from origin plotting line for unit No. 3 upside down from the way shown in Fig. 1, Line No. 1.

Another momentary performance chart is shown on Fig. 4 for 5:10 p. m. The total load is then 3050 kw., the load being divided as follows: No. 1 unit 1425 kw. No. 2 unit 1425 kw. No. 3 unit 200 kw. The rate of steam flow through throttle is 61,300 lb. The rate of total amount of low-pressure steam per hour is 15,000 lb.

The above cited performances are those that are actually desired. It is evident that as a general rule they are not obtained. Instead of the load dividing in this manner, it will divide depending on a number of circumstances, chiefly characteristics in the speed governors on the respective units.

Also it will be noted that the load of the noncondensing turbine must vary with steam demand, and the condensing machines must furnish the balance between power required and what the noncondensing machines give. Hence, it will be understood that in a power plant with some condensing and some noncondensing operating units, it is necessary that the condensing operating machines are capable of developing the maximum load of the station minus the load developed by the noncondensing unit or units, with the minimum amount of steam required in addition to that developed by the auxiliaries, all of course assuming ideal conditions are desired.

If all machines operate in parallel the load of the noncondensing machines could be varied as stated above. There would, however, be considerable difficulty in changing the load of the units for every small change of station load unless some automatic control could be used.

In order to show the interesting form of these performance sheets when one of the units is a low-pressure machine, an additional curve, Fig. 5, is drawn up for the case of performance at 3:50 p. m. if the units available, instead of those previously mentioned, were as follows:

1—1500-kw. noncondensing unit. Performance as per Line No. 1, Fig. 1.

1—1500-kw. low-pressure turbine. Performance as per Line No. 1, Fig. 6.

1—1500-kw. condensing turbine. Performance as per Line No. 2, Fig. 1.

With 1—1000-kw. condensing unit as a spare machine.

It will be noted in this instance that the performance line of the low-pressure turbine is also plotted in the third quadrant, but in a positive or upward direction. The total amount of steam at the throttle will be 79,000 lb. per hour, or about the same as with the actual arrangement described before. The total power of 3500 kw. is distributed as follows: Condensing unit—1500 kw., noncondensing unit—1460 kw., low-pressure unit—540 kw. The total amount of low-pressure steam available at the exhaust of the noncondensing operating units is 54,800 lb. Of this 16,800 lb. is consumed by the low-pressure turbine.

Automatic Control Demanded

Observing these momentary performance curves and considering the fact that in order that the best possible economy of heat may be obtained there is always one certain load which each unit should carry, one realizes the utter impossibility of obtaining the best economy of operation in plants where there is no automatic control over the distribution of the load. Especially will the losses be great in such plants where the load and rate of steam demand fluctuate widely and rapidly.

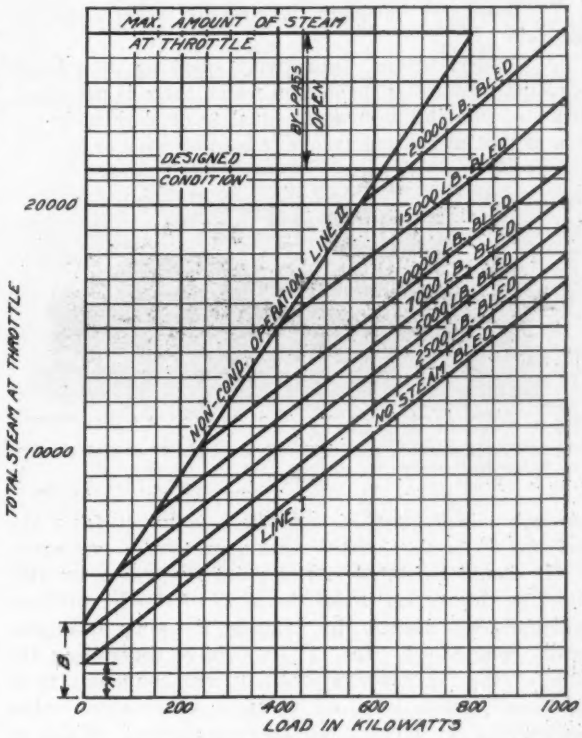


FIG. 9. RELATIONS BETWEEN TOTAL STEAM AT THROTTLE AND POWER LOAD WITH DIFFERENT AMOUNTS OF STEAM BLED

Generally owners and operators of power plants do not realize the magnitude of these losses until they have actually, by installing some automatic device, removed them and then notice the difference in coal consumption.

While in the majority of small plants using condensing, noncondensing, low or mixed-pressure units, no automatic control for the distribution of load is being used, it may be stated that such controls have been devised and are on the market. It should be unnecessary to say that the importance of such controls cannot be too strongly emphasized, especially in plants with fluctuating loads.

The bleeder or extraction turbine has certain distinct advantages over any other arrangement.

1st. It serves as a combination noncondensing, high-pressure, condensing and low-pressure turbine and

permits of the very best heat balance even where there is only one or two main units.

2nd. The flow of steam to a heating system being determined by the pressure of that system, the load to be carried by the high-pressure and low-pressure elements, in order to result in proper heat balance, is determined by a governor mechanism operated by pressure at this point. Consequently, this is done automatically and does not have to be varied by the operator.

3rd. Generally the bleeder type of turbine will work out more advantageously than any other arrangement, considering any of the following points:

a. Floor space.
b. First cost of machine.
c. Cost of installation.
d. Cost of maintenance.
e. Steam economy.
f. Generator efficiency because of larger capacity per unit.

A bleeder turbine, figuratively speaking, is a high-pressure condensing turbine on which there is provided, in a stage having a pressure equal to or slightly in excess of that in heating system, a lead-off pipe or bleeder

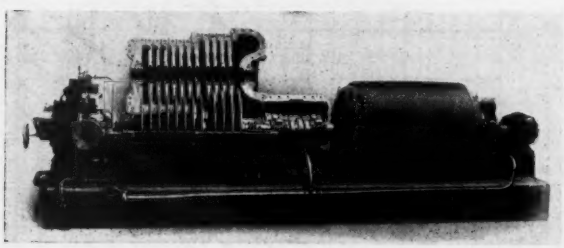


FIG. 10. VIEW OF A BLEEDER TYPE TURBINE WITH CASING RAISED

through which part of the steam is taken from the turbine while the balance continues to the condenser.

It should be stated at this point that there are turbines on the market under the name of bleeder turbines which do not deserve the name in the sense it is generally understood. Instead of a valve controlling the flow of the low-pressure steam to the condenser these turbines have a balanced valve in the bleeder outlet controlling the flow to the heating system. While an ordinary bleeder turbine, particularly of the multi-stage type, may be designed to give exceedingly good performances, the above-mentioned machines are very wasteful in that they, in order to bleed any steam at all for low loads, must throttle the steam to a considerable extent for higher loads.

Specified Operating Conditions

Bleeder turbines are generally designed for conditions as follows:

1st. Nearly all bleeder turbines are required to carry full load bleeding no steam; in other words operating straight high-pressure condensing.

2nd. A considerable number of bleeder turbines are designed so as to permit the extraction of all steam at times if necessary; in other words, to operate non-condensing. The low-pressure end of the turbine will then be carrying no load and its rotating element will be revolving in a vacuum. Generally bleeder valves in turbines are made so as to permit a certain amount of steam to pass through these low-pressure stages to the condenser, in order to prevent high temperatures in the low-pressure end of the turbine as a result of insufficient dissipation of heat energy created through windage friction between the rotating elements and the surrounding thinned out air or vapor.

As is commonly known, the flow of steam through any type of turbine is very nearly proportional to the pressure at the entrance of the nozzle in the first stage, or what is commonly known as ring pressure. As a consequence, the nozzle areas through the high-pressure stages must be larger than those for a straight high-pressure condensing turbine, they must in fact be large enough to accommodate the steam necessary to give the maximum power to be developed by the high-pressure elements when bleeding the maximum amount of steam. If the machine is required to carry full load noncondensing, the areas will be more than twice as a rule for those of a straight condensing turbine. A

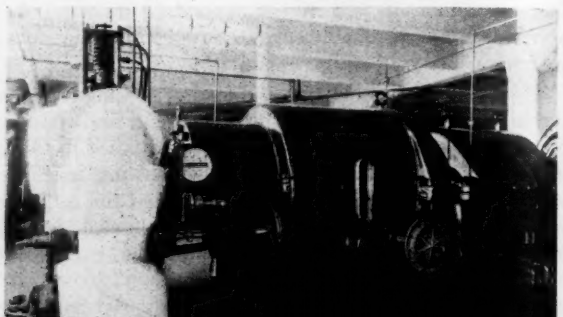


FIG. 11. EXTERIOR VIEW OF BLEEDER MECHANISM

parallel to this is the case of a cross-compound engine from the intermediate receiver of which is bled a considerable amount of steam, in which case the high-pressure cylinder is increased beyond the proportion relative to the low-pressure cylinder which it would have for high-pressure condensing operation.

When considering that there is generally no difficulty in providing the proper areas for the steam in the high-pressure stages of a condensing turbine, but that the limitations as to capacity are reached in the last stages where the areas have to be large to accommodate the low-pressure steam with corresponding high specific volume, it will be clear that a certain frame used for a certain capacity for high pressure condensing service would be good for a considerably higher capacity when used as a bleeder turbine where a part of the steam is discharged at atmospheric pressure. This is one of the reasons for the superiority of the bleeder turbine when first cost is considered.

Naturally, designing the high-pressure stages with large areas to accommodate the steam for the condition where the maximum amount of steam is being bled will adversely affect the steam economy of these turbines when operating high pressure condensing, without bleeding steam. This, however, is generally cared for on

Curtis or combination Curtis-Rateau machines by the use of valves controlling the flow of steam to the first stage nozzles and on turbines with a larger number of stages, such as Rateau type turbines, by the use of automatic opening and closing throttle valves controlling sections of the nozzles in the first stage. The nozzles in between the first stage and the bleeder stage will in this way in any event be larger than necessary, but the loss resulting from this will be small. The low-pressure stages, or those between the bleeder and the condenser, will always be designed to accommodate the steam necessary to develop full load bleeding no steam, with the bleeder pressure as initial pressure and the proper vacuum as terminal pressure.

In Fig. 7 are shown two curves illustrating the full load absolute stage pressures and the total nozzle areas in each stage of a 1000-kw., 10-stage, high-pressure, condensing turbine designed for 200 lb. initial steam pressure and 28 in. vacuum at the exhaust.

In Fig. 8 are shown in heavy lines similar curves for a 1000-kw. bleeder unit of the same frame and general design, so proportioned as to allow it to bleed from its fifth stage 10,000 lb. of low-pressure steam, under 5 lb. back pressure at full load without opening any overload valves. In addition, there are also shown for comparative purposes in Fig. 8, in light lines, the same curves as indicated in Fig. 7.

It will be noted that all the areas in the five high-pressure stages of the bleeder turbine are considerably greater than those for the high-pressure condensing turbine. At the sixth stage, however, the areas nearly coincide and the two lines continue close together up to the tenth stage with the areas in the bleeder turbine slightly greater than those in the straight high-pressure condensing turbine. The stage pressure line for full load is exactly the same for both turbines, when the bleeder turbine is bleeding 10,000 lb. of steam. However, when this is not the case the high-pressure stage pressures will, as may be seen, lie somewhat lower than those in the high-pressure condensing turbine.

A 1000-kw. bleeder turbine if designed to carry full load and bleed 10,000 lb. of steam may be, and generally is, so made as to allow the bleeding of an additional amount of steam by opening an overload valve, either admitting steam into an additional segment of the nozzles in the first stage, or bypassing it into a following stage, in both cases allowing the nozzles to pass a greater amount of steam, hence develop more power at some slight sacrifice in economy, in the former case through raising of the pressure in the first stage and as a result also those in the adjacent stages, hence lowering the specific volume, in the latter case allowing part of the steam to pass by one or more stages and admitting it into a stage with greater nozzle area.

Similarly, this bleeder turbine can, if only 10,000 lb. maximum is desired, have its nozzles in the first stage designed for full load bleeding no steam, with an overload valve to open when bleeding the maximum amount of steam and carrying full load.

Overload valves or bypass valves are preferably made automatic, especially in cases where the load fluctuates. If hand valves or so-called "nozzle valves" are used, operators fearing sudden increases in load generally leave them open at all times, thus causing loss in efficiency for light loads.

The actual design and proportioning of an extraction turbine and the calculating of its performance under the various conditions, offers some exceedingly interesting problems. To further illustrate the characteristics of this type of turbine there has been shown in Fig. 9 the summary of such performance calculations for the above-mentioned 1000-kw. bleeder unit. It will be noted that there are two main lines (I and II), the former one illustrating the performance operating condensing without bleeding any steam whatever, and the latter the noncondensing performance or bleeding all the steam passed in at the throttle. Neither one of these curves goes to the origin. The two distances (A) and (B) illustrate the amount of steam necessary to run the turbine and its generator at full speed for no load, condensing and noncondensing operation, respectively. It will be noted that at full load, bleeding no steam, the total amount of steam is 16,800 lb. or the water rate 16,800÷1000 = 16.8 lb. per kw.-hr. At one-half load, bleeding all the steam, hence running noncondensing, the steam consumption is 18,000 lb. total, or 18,000÷500 = 36 lb. per kw.-hr.

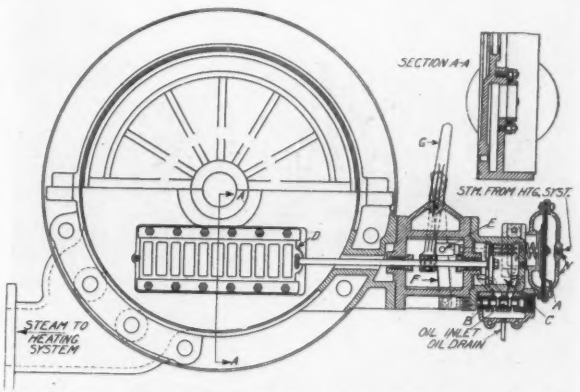


FIG. 12. CROSS SECTION SHOWING MECHANISM CONTROLLING AMOUNT OF STEAM PASSING TO THE CONDENSER

Bleeding the maximum amount of steam without opening overload valves and developing full load, the total steam at the throttle 21,600 lb.—hence the water rate is 21.6 lb. per kw.-hr. when 10,000 lb. of steam is bled at 5 lb. back pressure and the balance of 11,600 lb. of steam continuing to the condenser.

The performance at any load and bleeding any amount of steam may readily be arrived at by using this diagram.

As stated before, bleeder turbines are often designed to bleed all steam admitted at throttle. This is always done at some additional sacrifice in steam economy when running high pressure condensing.

Detailed Description

The construction of a bleeder turbine is illustrated in Figs. 10, 11, 12 and 13. The first one of these figures shows the general construction of the casing of this type of turbine. As will be noted, the casing consists of the two end castings, the steam end and exhaust end, between which are the diaphragms. The sectional construction of this type of machine lends itself excellently to the varying and complex conditions encountered in the design of the bleeder turbine. Without great expense each stage can be made to have its noz-

zle area correct for any certain condition of operation. As is commonly known, the efficiency of any type of turbine, not considering windage friction, is the function of the ratios between the blade and steam velocities. By adding stages for special conditions—low rotative speeds, high steam pressures and good vacuum—and removing stages for conditions in the opposite extreme—high rotative speeds, low steam pressures and high exhaust pressures—it is possible so to adjust the number of stages as to get the best possible performance under all conditions. The fact that diaphragms can be added or removed from a certain frame of this type of machine without hardship, gives it in the majority of cases a natural and initial advantage over other types of machines with solid frames or casings.

Figures 11, 12 and 13 further illustrate the details of the bleeder mechanism. This consists of a grid valve which controls the amount of steam passing through the condenser and regulates the amount of steam forced out of the bleeder outlet connection. This valve is

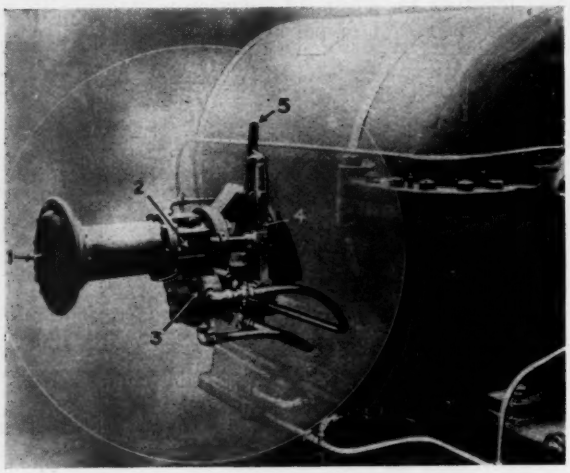


FIG. 13. DETAIL OF BLEEDER MECHANISM

shown at point D in Fig. 12. The movement of this grid valve is caused by steam pressure conditions in the system receiving the steam bled from the turbine. A pipe connects the receiving system with the operating end on the regulating diaphragm illustrated in the same figure, which acts as a pressure governor. Movement of this diaphragm is controlled by the pressure resisted by a compression spring (2 Fig. 13). As the pressure increases, the diaphragm goes to the left against the action of the spring. This motion of the diaphragm is transmitted to a lever F, (4 Fig. 13), pivoted at its upper end on lever G, (5 Fig. 13), and attached at its lower end to pilot valve B. Movement of the pilot valve admits oil under 35 lb. pressure to the cylinder C and moves the piston and also the valve D which is mounted on the piston rod. As this piston rod moves it changes the position of the lever G, which through its connection to lever F, returns the pilot valve to its neutral position.

Assume that the pressure in the receiving system falls, due to a sudden demand for steam pressure, pressure on diaphragm A decreases and the spring pushes this diaphragm to the right. Through a rod E connecting this diaphragm to lever F the pilot control B then admits oil to cylinder C and moves the piston to the left, so as to close the grid valve D. As this valve closes less steam can pass through to the condenser, hence is forced out the bleeder outlet into the receiving system and raises the pressure of the latter.

The motion of this piston and lever G together with increase of pressure on diaphragm A will return the pilot valve B to its neutral position at the time pressure in the receiving system becomes normal.

An increase of pressure in the receiving system will produce a reverse action and cause the grid valve D to open so as to allow steam to pass through to the condenser doing useful work in the last stages of the turbine. The pressure which the receiving system requires is regulated by the spring acting on diaphragm A.

The limits, of course, are the capacity of the turbine and the load on it at that time. If the bleeder valve is between the fifth and sixth wheels the turbine will run as a five-stage turbine when the grid valve is completely closed and all steam is being bled. If the turbine is running at no load the governor will only admit sufficient steam to maintain speed which amount may be only a few hundred pounds.

If the load is 200 kw. and the steam consumption of a five-stage turbine running noncondensing is 45 lb. per kilowatt-hour, then the total amount of steam admitted to the turbine by the governor would be 45×200, or 9000 lb. of steam per hour and this is, of course, the maximum amount that could be bled with valve D closed.

If less than this amount of steam was required and the load remained at 200 kw., then the grid valve would open and let steam pass into the vacuum stages. The extra power thus derived enables the turbine to carry the load with less steam so that the governor shuts off some of the supply entering. This action of the governor together with the admission of steam into the vacuum stages cuts down the quantity of steam entering the bleeder system and maintains it at the desired pressure. There is therefore always the action of the two governors and the combination of a noncondensing and partial condensing turbine entering into every change of demand for steam or mechanical load. The actions of the various parts are, however, very rapid so that speed and pressure are maintained constant at all times.

In certain instances of exceedingly close pressure regulation, the oil pilot is substituted with a steam relay. Certain installations have been made where the steam pressure does not vary to exceed 1/20 lb. of pressure for any amount of steam bled.

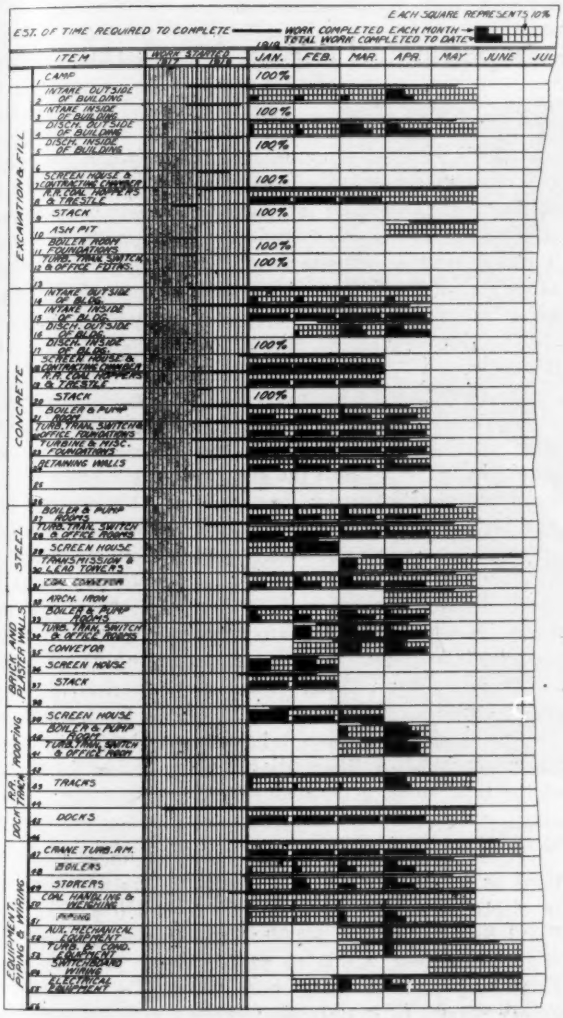
THE UNITED STATES SHIPPING BOARD announced, July 25, that two gigantic ocean racers swifter and larger than anything afloat are to be built by the board. Vessels will have 1000 ft. length with speed of 30 knots an hour; are to be oil burning and are designed to cross the Atlantic in four days. The board has in view construction of two more of same type, and is considering Fort Pond Bay as Atlantic terminal.

LOOSE QUARTERS may become lost quarters. Thrift Stamps tighten your hold on them.

A Useful Progress Chart for Construction Work

DURING the construction of the new Edgewater power station of the Lorain County Electric Co., of Elyria, Ohio, the engineers of the Utilities Construction Co. engaged on the project employed a very complete but simple form of progress chart. By means of this chart, which is shown herewith, it was readily possible to determine at a glance not only the percentage of work already done on any particular job, but also the percentage of work remaining unfinished and the estimated length of time required to complete the work.

PROGRESS CHART EMPLOYED BY UTILITIES CONSTRUCTION CO. DURING ERECTION OF EDGEWATER POWER STATION



For every month of the year and opposite each job two series of squares of ten each are provided in the manner indicated. The upper row is for the work completed during that particular month, the number of squares being filled in depending upon the percentage of work having been completed during that month. With the completion of 10 per cent of the work, but one square is filled in; with the completion of 20 per cent, two squares are filled in, and so on.

The lower squares represent the total work completed to date and as an upper square is filled in, so is a lower one, although the total number of lower filled-in squares is not necessarily the same as the total number in the upper row unless, of course, the job was completed during the month in question.

In item 2, which, under the general head of Excavation and Fill, represents the work done on the intake outside of the building, but 20 per cent of the work remained finished during the months of January, February and March of this year, after which, that is during April, an additional 40 per cent of the work was completed. Thus, as may be seen by referring to the lower row of squares under April, 60 per cent of the total job had been finished by the end of that month.

In the case of the screen house, item 36, under Brick and Plastered Walls, we find, due to the filling in of the first five squares of both upper and lower rows, that 50 per cent of this job was completed during the month of January. Work was evidently continued during February for, as shown, an additional five upper and all of the lower squares are filled in, thus indicating the completion of this job during the second month of the year.

During January, 10 per cent of the stoker installation, item 49 under Equipment, Piping and Wiring, was completed with an additional 20, 10 and 30 per cent added during February, March and April, respectively, thus showing that at the end of April 70 per cent of the stoker equipment had been installed.

In general, the chart is self-explanatory and the scheme employed should be of inestimable value to engineers in charge of construction work enabling them not only to accurately report the rate of progress of any work on which they may be engaged, but also to guide themselves in the purchase of material and the hiring of labor.

The Combined Internal-Combustion and Steam Engine

IN a paper read before the Royal Society of Arts, Captain F. E. D. Acland described an engine which has been developed by W. J. Still, and which represents an attempt both to improve the efficiency of the internal-combustion engine and to eliminate some of its undesirable characteristics. Briefly the still engine is an internal combustion engine, the cylinder of which is jacketed with hot water at constant temperature. Heat abstracted from the combustion cylinder is employed not in raising the temperature of the jacket water, but in converting it into steam. The jacket is connected up to the water space of a steam boiler and this water, on its journey to the jacket, is taken through a tubular heater through which the exhaust gases pass. The steam and water leaving the jacket are led to the steam space of the same boiler. The exhaust gases, on leaving the tubular heater are taken through a second heater, through which the feed water is drawn. The steam from the boiler is used in a steam cylinder which forms the underside of the combustion cylinder. That is to

say, there is but one piston and one cylinder, the upper part of which is an internal-combustion cylinder and the lower part of which is a steam cylinder. The down stroke is an internal-combustion stroke, and the up stroke a steam stroke.

Remarkable economies are claimed for this engine, and theoretically they may be admitted. It is stated that a final exhaust temperature as low as 150 deg. F. is obtained, so that the working temperature range is large. The arguments for economy are based on the following main considerations. The high jacket temperature results in a higher mean temperature than usual in the combustion stroke, which improves efficiency. All heat rejected to the jacket is recovered directly as steam and not in the form of hot water difficult to use effectively. The steam cylinder, it is claimed, gives unusually good results, since as the cylinder is preheated by the combustion stroke there is no condensation and the steam is rejected to exhaust slightly superheated. From an operating point of view it is claimed that as the steam warms the engine before starting there are no sudden temperature changes, and that the steam allows the engine to be started against load. In Still-Diesel engines it is further claimed the compression pressure may be reduced by 50 per cent with entirely reliable ignition, owing to the higher mean temperature of the cylinder.

Apart from increased efficiency, it is clear that the Still engine, in virtue of its steam feature, also attempts to improve the flexibility and starting properties of the internal-combustion engine. This, however, is only done by adding all the features of a steam engine to it. Dealing above with the claims made for the engine, we referred to the statements that there was no sudden temperature change at starting and that it could be started against load. If, however, we understand the engine correctly these features can be obtained only by fitting the boiler with an independent fire-box and raising steam before the engine is started. This, of course, can be done, and the independent fire-box is a feature of some applications of the engine, but these peculiar starting virtues of the steam engine have only been obtained by sacrificing one of the main claims of the internal-combustion engine—that is, that it requires no external boiler and can be started up at any time on short notice and without preliminary preparation.

To quote some of the figures given, we may refer to tests on a four-stroke single-cylinder engine described as of the explosion type. The class of fuel used was not stated nor was the power or size of the engine, which, however, we take to have been small, as the test was an early one. In this case, 29 per cent additional brake horsepower was added to the shaft of the engine without increase in the fuel consumption and with steam exhaust to atmosphere. The addition of a condenser raised the added brake horsepower to 40. It was stated, however, that the air pump was driven separately. As we read the figures, nothing has been debited from the engine for this work.

A single-cylinder petrol engine, with condenser at the steam end maintaining 25-in. vacuum, had a brake thermal efficiency of 36 per cent and used an average of 0.42 lb. of fuel per brake horsepower over a 4-hr. run. Again, however, the condenser pump losses were not included. A Still-Diesel engine with compounded steam side had a consumption of 0.302 lb. of Admiralty shale oil per brake horsepower over one hour's run. "Scavenge pump not included." This engine developed 330 b. hp. under waste heat conditions. Several figures are given for the output of this engine with extra added steam, but they are not material from our present point of view. A good deal of practical work appears to have been done in running these engines with added steam. As we understand it, the idea is that for both marine and locomotive work the possibility of such added steam is looked upon as an important possibility of the engine. For normal running waste-heat steam only would be employed, but at starting and for overload the added steam would give the flexibility of an ordinary steam engine.—ENGINEERING.

Superheated Steam for Auxiliaries

BY MARK MEREDITH

THE USE of superheated steam for the driving of auxiliary machinery on board ship, when the main engines are supplied with superheated steam, is coming more and more into favor as it gets to be better understood, and as more engineers have experience with it and learn its advantages at first hand. Most engineers realize the disadvantages and dangers of excessive water in the steam fed to their auxiliaries, and these can, to a large extent, be eliminated if superheated steam is employed.

Particular care, however, will have to be paid to the problems of starting up and of lubricating during running. It has been suggested that a cross connection should be made between the auxiliary steam line and the main superheated steam line. When this is done, all auxiliaries are started up on saturated steam, and as the cylinders and valve surfaces get worked in, superheated steam can be cut into the line. This is done as gradually as conditions require, and at first only dries out the steam, eventually all the auxiliaries being operated on superheated steam, the degree depending entirely on the conditions prevailing. The use of superheated steam for the auxiliaries is 15 per cent of the total, and putting the saving due to superheating at 20 per cent, then the steam saved in the auxiliaries alone will be 3 per cent of the total steam generated.

U. S. CIVIL SERVICE COMMISSION announces examinations as follows: Sept. 2—Electric Engineer (qualified in electrical safety work), $2800 to $3300 a year, and Plant Superintendent, $2000 to $2400; Sept. 9—Specification Engineer, $2000 to $2400; Sept. 16—Electrical Engineer, $2400 to $3600, and Assistant Electrical Engineer, $1800 to $2400; Sept. 17, 18 and 19 and Nov. 19, 20 and 21—Assistant Examiner, Patent Office (Male and Female). Apply, stating the title of the examination desired, to the Civil Service Commission, Washington, D. C.

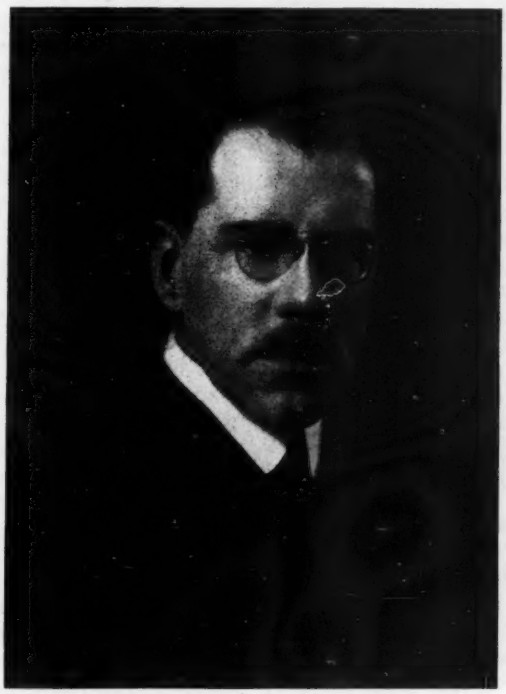
FOR GOOD RESULTS from r. t. boiler flues as heating surfaces, the smoke area of the flues usually is made 1/7 to 1/8 the area of the grate; but with tight connections, easy courses for the smoke and good stack draft, an uptake area 1/10 of the area of the grate will be sufficient. COMBUSTION CHAMBER.

WALTER N. POLAKOV

PHYSICIAN TO ANEMIC POWER PLANTS AND DISCIPLE OF DOING ALL THINGS WELL. ONE WHO UNDERSTANDS THE STRESS AND STRAINS OF MEN AND MATERIALS. BY E. LAZAROVICH-HREBELIANOVICH

OUTSTANDING among men who possess the peculiar ability to harmonize men, materials and methods for the betterment of the men, who has served as a wheel-horse in bringing the benefits of scientific methods into the power plant with its multiplicity of factors, is an engineer named Polakov.

"It is not the equipment and supplies that produce results but the mode of their use." These recent words of Walter N. Polakov formulated a maxim which he has been for several years ceaselessly testing and illustrating in this country in connection with various plants.



His definition of sensible management brings into precise scientific formulation the dictum of Dr. F. W. Taylor that "the art of management is knowing exactly what you want men to do and then seeing that they do it in the best and cheapest way."

Mr. Polakov's version is "management cannot be termed scientific until 'what you want' and, 'how to do it' are based on scientific certainty, and not on habit, tradition, hearsay or superficial knowledge. Thorough, minute and unbiased research work must precede the introduction of new methods. No two plants being alike in design, location, supplies, attendance, or service, each case must be studied individually and the practice modified to suit the conditions, though the principle of procedure remains the same. . . . Apply scientific analysis and then synthetically devise: First, the Aim; second, the Means. When all the possible numbers of solutions have been shown, the selection of the most rational result from the interplay of causes and the arrangement of causes to obtain the desired result, constitute the art of the introduction of scientific management."

Taken from the report of the Warrior Ridge power plant work a single citation is indicative of methods and results of Mr. Polakov.

" . . . 180,000 lb. of coal were handled by four men in 24 hr.; two men working together for 12 hr. and passing 45,000 lb. each could not stand the work. It was too hard. This was because the shovel had a short handle and they had to bend too low, because the shovel held only 16 lb. of coal instead of 21 lb., causing too many bendings per ton; and because the wheel-barrow held only 250 lb., causing too many trips. When a man was given the right kind of shovel and a wheel-barrow holding 400 lb., yet throwing less weight on the arms when lifted loaded, he handled 65,000 lb. in 8 hr.—instead of 45,000 lb. in 12 hr.—and thought the job easier than before."

One important factor of Mr. Polakov's instruction card was the strict observance of frequent and fixed rest periods, to be taken sitting. That general instruction card relating alone to the "passing coal from coal bin to front of boilers in 400 lb. wheelbarrow on concrete floor" contained 30 items, following which the work was performed with ease. All divisions of the operation of the power plant were similarly regulated, each being covered by a special instruction card, tried out under careful personal observation of Mr. Polakov.

Mr. Polakov has found that more economical operation of plants in no instance means harder work for the employes. The reverse is true; there has been less coal to shovel, less emergency repair work done through proper tools and tool care, less exciting nerve-racking responsibility on the part of the employe, because of the definiteness and organization of his task.

Part of this system is a bonus to the men "for the accomplished task," but never given for any increase or surpassing by the workman of that "assigned task" which is undesirable, as fatigue and strain are to be strictly avoided. This bonus is in no sense a premium,

but is merely extra compensation given for the exercise of extra intelligence and ability in learning to do correctly and rapidly "what is taught."

Before the American Society of Mechanical Engineers, Mr. Polakov showed that "the common practice is to charge against the cost of product the cost of over-equipment and mismanagement; thus imposing on society the penalty for tolerating these conditions in industry."

He put forth the new principle for which he claims immense importance: That if the cost of the possession of the idle means of production were charged against the capital, and not against the product, the results would be: (1) stimulation of product, (2) decreased cost of commodities, (3) increased value of labor, (4) larger consumption and turn over, (5) possibility of reducing working hours.

The well-known formula: "Capital, plus Labor, plus Management," shows Management to be the controlling factor of all success. Indeed, "Labor starting without Capital, but plus good Management has won success, but Capital and Labor joint, but minus Good Management has always spelled Failure."

Walter N. Polakov thinks not alone in terms of money-gain to the firm, but in terms of usefulness of industry and business to all therein engaged and to the community. While things are being made, men and women must be made, human material must not be destroyed. There must be no inert capital, for even while it is in the act of being produced and increased, it must be already creating life for lives. Important to note in this achievement are two aspects, with these new principles of industrial development: (1) industry for the first time will come to stand on a secure basis with increased capacity of obtaining financial returns, and (2) labor for the first time, under such conditions receives due consideration, not as charity, but as a business factor, a situation productive for the first time, of legitimate grounds of confidence between employer and employe, between labor and capital.

In many ways the career of Mr. Polakov is an illustration of the values of the principle he advocates. Born in Russia in 1879, he was in turn, in Russia: Assistant Superintendent of Locomotive works of the Tula Imperial Railroad; Chief Engineer of the Department of Navigation and Harbors of the Ministry of Commerce and Labor, Instructor and Consulting Engineer to the Naval Academy of the same Ministry at Baku. He left Russia for political reasons and came to the United States, where, after mastering the language, he became connected with Harrington Emerson, the standard-practice engineer of the American Locomotive Co. Later, he was consulting engineer to the Board of Estimates and Apportionment of New York City, carrying on investigations of preventable wastes and losses in the municipal power plants. By the introduction of his methods he saved the city, in one year alone, in the Water Department of the Borough of Brooklyn, about one quarter of a million dollars, while the Department of Docks and Ferries, operating on Mr. Polakov's plan, saved $116,000, thereby almost wiping out the former operating deficit.

Parallel to the remarkable results he obtained for the Penn Central Light and Power Co. at their Warrior Ridge plant and other public utility properties were the economies effected as superintendent of the Power Department of the New York, New Haven & Hartford R. R., in charge of 13 power plants and the entire electric traction, heat, light and power of the system. There electric energy cost was reduced from nearly $0.07 per kw.h. to less than $0.05 per kw.-hr. During the summer of 1918 Mr. Polakov, as Power Expert of the United States Shipping Board for the Emergency Fleet Corporation, instigated the reorganization of the production methods of The Philadelphia Electric Co., a group of recommendations which altogether resulted in the possibility of uninterrupted industrial operations in Philadelphia, and eliminated the necessity for an outlay by the country of 20 million dollars on new generating equipment.

In view of the present alarm over the expected coal shortage, it is interesting to note Mr. Polakov's opinion, that if the wastes in the consumption and handling of coal in power production were eliminated, the enormous saving from that source alone would meet over ⅓ of the present coal shortage of some 140 million tons in the United States.

The father of Mr. Polakov, who was the President of the Supreme Court of Russia, spared no effort to prepare him for a diplomatic career in accordance with family tradition—but his own inclinations were different—he wanted to do "something for the people rather than to do them." So he went abroad to Germany to study engineering and where he was fortunate enough to have among his Professors, such men as Zeuner and Hempel. After he got his degree, he felt that the engineer has to deal more with human materials than with matter and forces—hence his post-graduate courses in psychology and medicine.

Mr. Polakov has lectured before the post-graduates of the Sheffield School of Science of Yale University and is a contributor to various professional papers. He is the author of a recent series of articles on the Mastery of Power Production which form the basis of a book now in preparation.

Polakov the man—his body fashioned after the likeness of Hephaestos—perhaps inspired Prof. Breckenridge to say: "Polakov will never get to Hell because he knows too much about the saving of coal. In that body ill-treated by Nature there is a heart, large and true, yearning to help and be of service to his fellow men. The children, good judges of human hearts, look upon him as their trusted friend and playmate, and many an hour of his spare time is passed in playing with them in the streets near his home. Flowers are his weakness; paintings and music his recreation; and work he calls his sport. Like Hephaestos, he finds his joy near the boiler, the fire grate, the bellows, amidst the din of hammers and the whir of machines. In life there is no halfway for him—better the bitter fight to the end than luke-warm indifference."

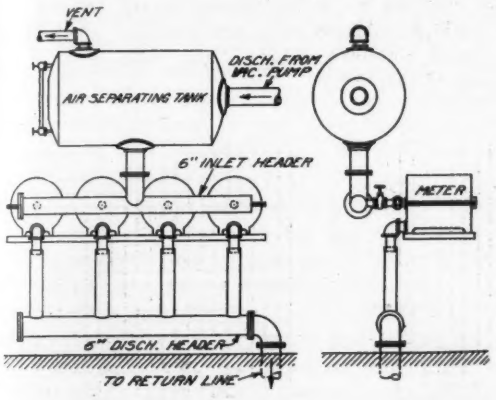
Mr. Polakov is a citizen of the United States and a warm supporter of American ideals—a believer in American Destiny.

DON'T WAIT to get that large sum for investment. Put all the little bits in Thrift Stamps and War Savings Stamps and you will soon have a large sum invested.

Efficient Condensation Meter Installation*

By L. E. Croup

In the case of large office buildings, hotels, etc., it is often found necessary to install from three to five condensation meters to take care of the maximum demands, or else to have a special meter made, large enough for the entire job. The advantages of using several meters are many. Most buildings use a small amount of steam during the summer months for water heaters, etc., and greater accuracy can be maintained by using a small meter rather than a large one. It has been proven by tests that meters nearly always have a greater error when the load is small. Increased accuracy can be maintained by the use of two or more meters, because of the fact that the effect of a possible large error in a single meter is diminished. When one of the meters stops registering, the method of estimating can be made much easier, from the fact that each meter in an installation of this kind registers practically the same percentage



TYPICAL METER INSTALLATION FOR LARGE BUILDINGS

of the total condensation at all times. The accompanying sketch shows the method used by the Duquesne Light Co., which has been made a standard for installations of this kind.

On vacuum heating systems, it is necessary to have a storage tank ahead of the meters, which at the same time serves as an air separating tank, for if the air is forced through the meters, their accuracy of registration will be affected. The tank also allows the condensation to flow by gravity to the meters and eliminates the chance of putting a pressure on them. The installation can be located at a high enough elevation to allow the condensation to flow back to the plant when so desired.

Both inlet and discharge headers are made in one piece with welded nipples, which minimizes the number of fittings necessary and chances for leaks. The outlet pipe from the meter is extended loose into a larger nipple in the discharge header. This is done for two reasons. It greatly reduces the work when it is found necessary to remove a meter for testing or any other purpose; it makes sure that all condensation will flow away from the meters, and not back up into them in case the return line should become clogged or stopped up in any way. The return line should always be well vented, for if any air collects in pockets in the line, much trouble will be experienced. This method allows the condensation to overflow at the meter outlet, and therefore, does not affect their operation. For such emergencies it is advisable to have a sewer drop close to the meter installation.

*From a paper presented at the 1919 convention, National District Heating Association.

Preparation of Fuel Before Delivery to the Fireman*

Much has been said, in times past, with regard to methods for obtaining improved boiler room performance. The tendency has been to center such discussion around the use of various types of instruments. While it is not the intention of this committee to belittle the use of instruments such as draft gages, flue gas analyzing apparatus, pyrometers, steam flow meters, etc., it is the belief of this committee that if there is one thing of more importance than any other, in the obtaining of good boiler performance, it is the proper preparation of fuel before it is fed to the fires. If fuel is not properly prepared, the best efforts on the part of the fireman will bring comparatively small results, and while, of course, there must be considerable variation in what constitutes the proper preparation of fuel, according to the kind of coal, the type of stoker, etc., involved, fundamentally, the important thing is to ascertain for each installation and location what the best conditions are by making observations and by conducting proper tests, and then so to manage the fuel supply to the fireman as to obtain the greatest uniformity possible.

Experience has shown that there are three things of prime importance:

1. Uniformity in the quality of coal. This does not necessarily mean coal containing the same number of B.t.u. per pound. Experience has shown that coals containing the same number of B.t.u. per pound have vastly different values according to their percentage of ash content and their ability to ignite readily, and experience has shown that due to the upsetting of the furnace performance, frequently a few cars of coal, which may be purchased at a low price per ton, will really turn out to be an expensive purchase.

2. The best size for feeding the coal to the furnace should be determined, and then, this size maintained as uniformly as possible. In the case under discussion there should be practically no pieces enter the furnace of a size that will not pass through a 1¼-in. ring, and approximately 90 per cent should pass through a ¾-in. ring. At the same time, the quantity of fines which will pass through a ¼-in. ring should not exceed 30 per cent.

3. Coal should be properly wet, and sufficient time must have elapsed between the time of wetting the coal and feeding it to the fires, to permit proper curing. Considerable has been said pro and con on the question of wetting coal. Explanation has been sought as to why the proper wetting of the coal improved the furnace operation, but no entirely satisfactory reason has been found.

*From a paper presented at the 1919 convention, National District Heating Association.

Growing Demand For Industrial Power

SOME STATISTICAL DATA GATHERED IN THE UNITED STATES AND THEIR ECONOMICAL SIGNIFICANCE TO THE COUNTRY. BY L. W. ALWYN - SCHMIDT

DURING the 15 yr. from 1899 to 1914 preceding the war, the value of the industrial production of the United States has grown from 11 billion dollars to 24 billion dollars. During the same time, the primary horsepower employed rose from 10,097,893 hp. during the year 1899 to 22,547,574 hp. during 1914, while the number of wage earners, the man power unit, showed a rise from 4,712,763 to 7,036,337 only. Turned into percentages, these figures represent an increase in the value of production of 118 per cent, in that of mechanical power of 120 per cent and that of man power 75 per cent. This already shows that man power has not kept up the same rate of increase as the two remaining factors. To produce one billion dollars value of our national industrial production, 917,999 hp. of primary power were required during the year 1899, 963,407 hp. during 1904, 933,768 hp. during 1909 and 939,482 hp. during 1914. For the same production, 428,433 units of man power were required during the year 1899, 390,598 units during 1904, 273,419 units during 1909, and 293,180 units during 1914.

Of rubber belting the production was valued at $2,093,000 during 1899 and at $10,594,000 during 1914, of leather belting at $3,123,000 during 1899 and at $7,556,000 during 1914. The value of the national production of electrical machinery rose from $42,976,000 in 1899 to $180,442,000 during 1914, but not all of that is consumed in power production and distribution proper.

The principal cause of this exceptional activity in the power industry of the country, of course, is the rapid evolution of many industrial branches from hand worked machinery to power machinery. Every installation engineer engaged in industrial work can tell of the increase of power equipment in his district. The garment industry, which 20 yr. ago was a hand crafts industry pure and simple, is now a power industry, the cobbler, the small artisan, all are employing power. By the effective use of mechanical power, in fact, it has been made possible to raise our national production to its present standard, where, "one man is able to do the work of two."

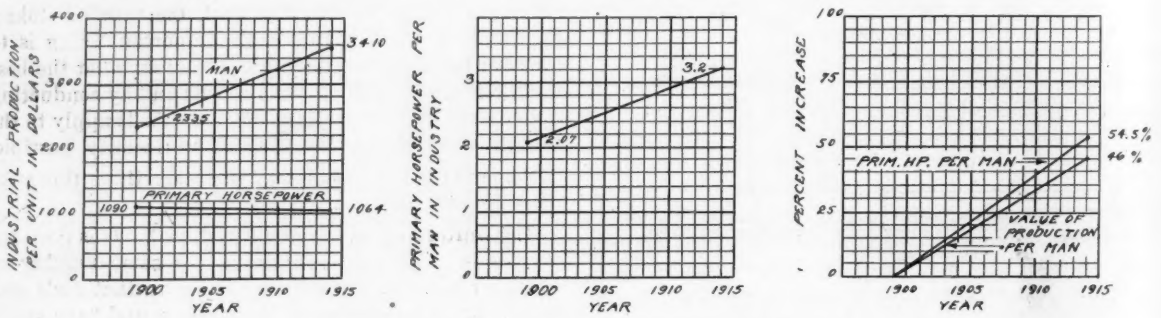


FIG. 1. SOME GRAPHIC DEDUCTIONS FROM STATISTICS

National production, therefore, is dispensing more and more with the application of man power in favor of an increasing employment of machine power. No doubt this process has continued during the present economic period and the coming census most likely will show a further decrease in the employment of human labor per each billion dollar unit of national industrial production and a corresponding strengthening of the application of machine power. The fact is of considerable importance for the future development of the American power industry. It is of vital interest for every engineer engaged in the production of power in this country.

Our census statistics are not explicit enough to permit an intimate study of the effect of this change in the application of power on all industrial branches of the power industry and the power equipment industry. The following figures, however, appear to be of interest:

During 1899, the value of all the gas machines, etc., produced in the country was $2,448,000. It had increased in 1914 to $9,066,000. The production of steam fittings rose from $11,865,000 to $37,001,000 and that of steam packing material from $1,948,000 to $6,037,000.

The period from the beginning of the present century to the outbreak of the war was one of rapid internal economic development. We have more than doubled our national production to satisfy the demand of our home market, which was outgrowing from year to year our industrial capacity, forcing our manufacturers to increased exertion. Whatever was added to the production of our factories by employing additional labor and by making more effective its industrial equipment was taken up immediately by the apparently insatiable consumptive abilities of the domestic market creating a permanent and not always successful race between the producing manufacturer and the consumer. Under such circumstances increase of production and not decrease in the cost of the article was the main point to gain. It did not matter that prices were rising if higher prices were acting as an incentive to additional production. Power was necessary to double if possible the productive efficiency of the human hand and mind, and it was this consideration which induced most manufacturers to make the jump from hand craft to power equipment, or to increase and perfect the power equipment where it was already in existence. No doubt the

invention of the stationary internal combustion engine, and the cheap electrical motor had a good deal to do with this development, making possible the employment of power machinery in many establishments, where the older forms of power production had proved to be either impracticable or too costly.

Since 1914 we have gone through the war; first as students of its economical effect on other industries, and later as participants in the struggle. It has changed practically entirely our industrial attitude. Instead of a small part of our industrial production going to foreign countries many of our industries have worked practically entirely for foreign trade. Quantity production and division of labor which in pre war times was more or less a convenience, suddenly had become a necessity. We have increased our productive effectiveness far above what we were accustomed to handle during peace time, and we find ourselves today with a many sided industrial equipment which can only in part find employment in the service of our domestic consumers. Work will have to be found for this equipment in the service of other markets. The employment of power therefore enters a new stage of evolution. Power must not aid any more only to increase our industrial production; it also must take its share in making our industry competitive in the world's markets. This is an entirely new aspect of our industrial life which it seems is only incompletely understood as yet by our manufacturers and power producers.

The cost of power is playing a considerable part in the national cost of production. During 1914 the American industry consumed for the production of its power 14,000,000 tons of anthracite coal, 166,000,000 tons of bituminous coal, 32,000,000 tons of coke, 48,000,000 bbl. of oil and gasoline, 285,000,000,000 cu. ft. of gas, 1,826,443 hp. of water power and rented 3,917,000 hp. of electrical power. The total cost of fuel and power to the industry amounted to $66,406,000. During the war we have learned a good deal, how to reduce the consumption of fuel. We have done this not with a view of saving expenses, but rather for the purpose of cutting down on fuel. Fuel preservation, therefore, has not always been identical with lowering the fuel cost factor in production cost. In fact experience shows that notwithstanding the strict economy followed by our industry with reference to fuel consumption, there has been a rapid increase in the expenditure for fuel all over the country. Unfortunately, there is little cause to expect a marked decrease in fuel cost. Coal mining is still as expensive as it was during the war, and with coal prices up in the air we can hardly expect a decline in other industrial fuels as gasoline, oil or gas. If our manufacturers, therefore, should make a serious attempt to cut down power cost, they will have to approach the problem from another point of attack than that of fuel. They will have to find a solution by employing the same means which they have applied to solving their earlier labor problems; they must reduce the individual application of power for the production of the manufactured unit.

The numerical employment of labor per manufactured unit has been reduced by taking increasing recourse to the employment of machinery and machine power. The growth in the demand for power must now be checked by reducing the power requirement of the factory equipment. Industry and engineering are meeting here on ground known to both. Reducing the power consumption of individual machines or whole factory equipments has been a matter that has already provided work to our power engineers during many years past. The consumption of power per manufactured unit did not progress as rapidly during the 15 yr. preceding the war as might have been expected from the general growth of industrial production. For each $1,000,000,000 worth of manufactures produced during the year 1899, $2,180,000,000 were produced during the year 1914.

During the same time, engineering replaced the production of the manual labor of 135,253 engaged in producing goods to a value of $1,000,000.

One can not say that our engineers have been very wasteful in handling the power factor of the additional industrial equipment installed during the period from 1899 to 1914 and permitting an additional production of nearly 13 billion dollars during one year.

Consumption and cost of power may be reduced by three distinct means. Of these elimination of waste, both as to fuel as well as to application of power, has found all the discussion it merits during the war. The other two apply to the production of power and its industrial consumption.

Inventors having applied themselves very effectively to the saving of power and fuel during the last four years have given little attention to the improvement of the power production of the engine itself. We can now expect a very rapid development in this direction. Will it be possible to get 2 hp. out of an engine which now produces only one, by changing its general construction? Power engine construction has made wonderful progress already during the last 30 yr. and there is absolutely no reason, why a new period of progress should not set in now. when there is so much to encourage inventors in their work. Never in the history of technical development has there been more call for the inventive genius, never have the means for making such invention and carrying out the required researches been more handy and in the reach of all.

What applies to the productive side of the problem fits just as well at the consuming end. We have constructed powerful machines to accomplish astonishing technical feats. Quantity production has been made possible by complicated automatic machines in a manner not suspected even by many trained technical men. But much of the recent progress has been obtained at the cost of power. When it is a matter of urgent necessity to cut a metal block of many tons weight, it probably does not matter whether a few hundred horsepower are applied where half that quantity might serve the same purpose. In the aggregate, however, such a surplus employment of power becomes exceedingly costly first to the machine shop and second to the nation. So it might well pay our engineers to make a study of the existing industrial equipment of the country and see where it may be corrected, so as to consume less power. Linking up related machinery, simplifying the action of certain parts and many other ways and means may suggest themselves to the engineer in search for improvements, and from one successful alteration a series

of similar changes may spring, leading to a reform of the power transmission equipment of the whole country. The actual saving may not be large on present-day showing. We are, however, still only in the early stages of this new industrial development and the result of our present vigilance may enable us in a few years to increase still more our national industrial production without the corresponding necessity of adding also to the application of power.

Such an occurrence would not mean essentially that the power producers would find less employment for their equipment nor would there be less demand for new equipment. On the contrary, it is more than likely that a permanent reorganization of our present system of power production, distribution and consumption on a basis of a permanent saving in all three factors would require much new equipment. Every new technical invention has invariably produced an additional activity in the industries affected by it. It is certain that a new inventive wave producing a series of fundamental changes in the technical handling of power would be followed by a corresponding extreme activity in making power machinery. Factories employing the antiquated equipment would soon be forced to replace it by the more modern engines as they would not be able to with-

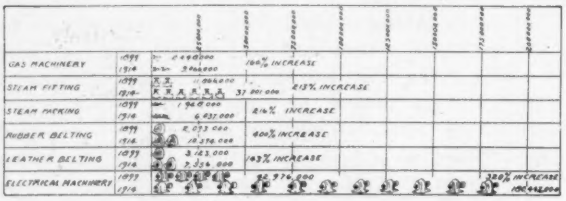


FIG. 2. VALUE OF ANNUAL PRODUCTION OF SEVERAL INDUSTRIAL PRODUCTS

stand the competition of the better equipped enterprises. And the changes would not be confined to the production of power. We know now that much was wrong with our present system of distributing power and that there is still plenty of room for improvement in the consumption end of it.

If means can be found to double the power production of a machine it must also be possible to find corresponding means to reduce the consumption of power by any given machine. The fact that we have gone along for many years without making any serious attempt to reduce the power consumption of many of our most important industrial implements is not a very good proof that this cannot be done. In fact, quite recently experience has shown conclusively that so simple a means as changing the transmission between the power source and the power consumer can alter entirely the rate of power consumption. We know little about all the factors influencing the consumption of power by any given industrial machine. We know, however, that certain machines seem to consume invariably an excessive amount of power where others go along with considerably less. The laws governing the requirement of power are known in principle while not always fully understood in all their parts. If it has been possible to add materially to our national production by increasing our national power consumption to what amounts practically to a fraction only, it seems that soon a time will be found when we shall be able to repeat this process without adding to it at all or where we shall actually reduce the present consumption of power.

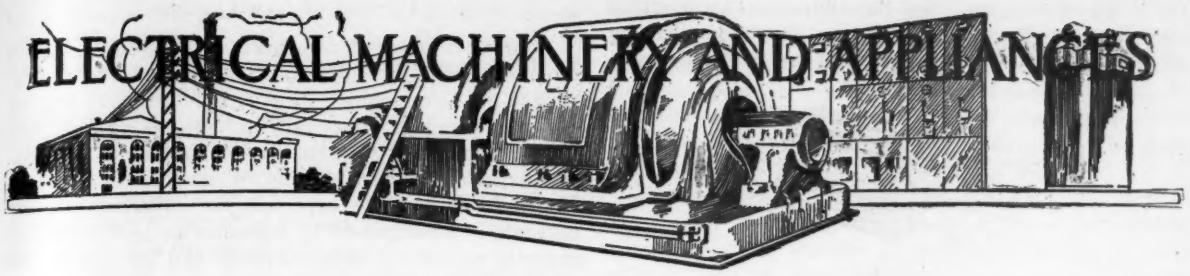
Such a reduction in the consumption of power, then, would provide also quite automatically a solution for the present problem of fuel consumption. We are still in the happy state where a few dollars more or less spent on coal, gasoline, or gas, do not seem to matter very much. But while we need not trouble as yet about the near exhaustion of our coal resources, there has appeared already now the much more pressing problem of raising the coal. It is easy to talk about adding a few millions of tons of coal every week to our production, but it may be more difficult one day to carry out such a proposal. Mining, although well paid, is not a profession appealing to everybody. There are a great many pursuits which are likely to draw labor in future, and as a result the day may come when the mining of coal will be limited by the supply of men willing to undertake the work of mining. Coal will then become either so expensive as to make its use for industrial purposes practically prohibitive, or we shall be forced to cut down its consumption to a level which may be much below even our present demand. It lies in the interest of the nation that such a development should not be hastened.

No doubt the next few years hold much in store for the American power industry. It is the life giver for all the millions of wheels turning in the American factories. From it we derive light, heat, and a livelihood. Its responsibilities have not been ended with the war. As it is said of many famous novels, their problems begin when the story ends. Something similar may have to be said of the problems of the power industry.

THE QUESTION as to where disabled ex-service men are being re-educated is answered by the fact that 5077 disabled soldiers, sailors and marines under the direction of the Federal Board for Vocational Education are in training in more than 700 different institutions throughout the country; 546 schools and colleges now number wounded soldiers among their students; and 198 commercial and industrial establishments have disabled men on their force learning the trade. In order to give the men the kind of courses they want as near their homes as possible, the Federal Board for Vocational Education has selected all types of institutions for their training. Elementary schools and state universities, the small service station, and the manufacturing establishments of the newest type of automobiles, Y. M. C. A. schools, trade schools, big shops and small shops, all vie with each other in giving their best training to these returned soldiers.

The courses they choose differ as the temperament of the men: 513 are studying some branch of agriculture; 721 have chosen manufacturing and mechanical pursuits; 289 are taking engineering courses; 104 are learning drafting and designing; 414 are now pursuing purely educational courses preparatory to a vocational course; 44 are taking law, and 64 medicine; those taking commercial courses number 1049.

More than 100 different occupations are being taught to disabled soldiers, sailors and marines under the administration of the Vocational Rehabilitation Act.



A Study of Dynamo Electric Machinery---VI

ARMATURE WINDINGS, COMMUTATORS AND BRUSHES. BY OTTOMAR H. HENSCHEL

ONE OF the earliest types of armature windings was the Gramme ring which will be reviewed here only for the purpose of making more readily understood, the principle of operation and construction of the type now in general use, the drum wound armature. Essentially the Gramme ring armature as shown in Fig. 34 and as its name implies consists of an iron structure of ring shape and with a so-called ring (sometimes termed helical) winding in which all of the conductors are connected in series. As explained in a preceding article, all of the conductors on one side of the neutral axis have induced within them an electromotive force equal to, but opposite in direction to that induced in the conductors on the other side of the neutral axis; however, due to these equal and opposite electromotive forces, no current can flow until brushes B and B are brought into contact with the commutator.

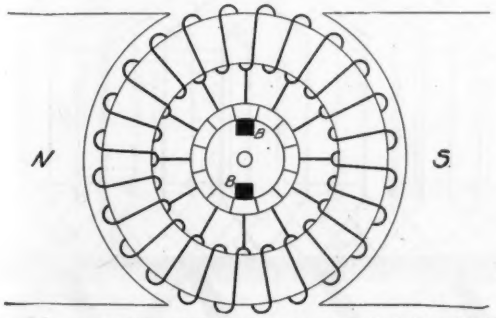


FIG. 34. A TYPICAL GRAMME RING ARMATURE WINDING

Just what occurs within an armature winding of this type is shown in Fig. 35. Only those sections of the windings on the outside of the supporting ring are active in the cutting of the magnetic flux and have, therefore, an electromotive force induced within them; for this reason, they are termed inductors. The remaining sections act merely as connecting links between the various inductors and although they are conductors, no electromotive force is induced within them.

Let us, for example, consider coil N, Fig. 35, and assume that the armature is rotating as indicated by the arrow in a clock-wise direction. Current is seen flowing in through the upper brush, commutator segment 2 and the attached connecting lead after which it divides, half going through the right-hand section of the winding and the other half through the left-hand section of which coil N is a part. However, as the armature moves forward, coil N enters the neutral plane (that is where the inductor of this coil cuts no magnetic flux) and as shown at B is at once short-circuited by the brush with the result that instead of the current passing through but one connecting lead, those attached to segments 1 and 2 are utilized.

With further advance of coil N, it again enters the magnetic field, but as the direction of its motion relative to the direction of the magnetic lines of force, has been reversed, the induced electromotive force and consequently also the direction of current flow is reversed as indicated at C.

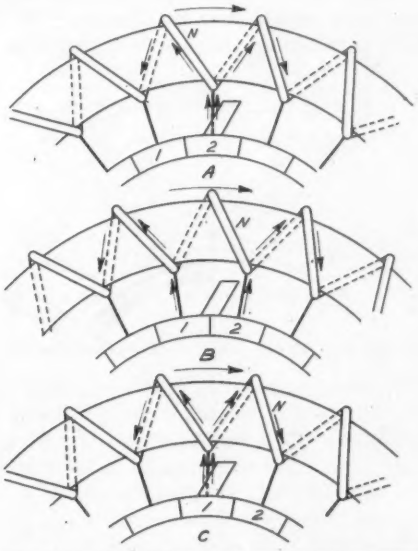


FIG. 35. SECTION OF GRAMME RING WINDING SHOWING PATH OF CURRENT IN COIL UNDER COMMUTATION

THE DRUM ARMATURE

IN THE CASE of the so-called drum armature, cores of the forms shown in Fig. 36 and built up of iron laminations well annealed and insulated one from the other by means either of a thin coating of rust or some high-grade insulating varnish are employed. Those used in connection with the smaller machines are mounted directly on the armature shaft being held in place by means of iron end heads secured by some form of lock

nut while on large machines, the laminations are mounted on cast spiders thus not only eliminating the employment of much otherwise useless material and thereby reduc-

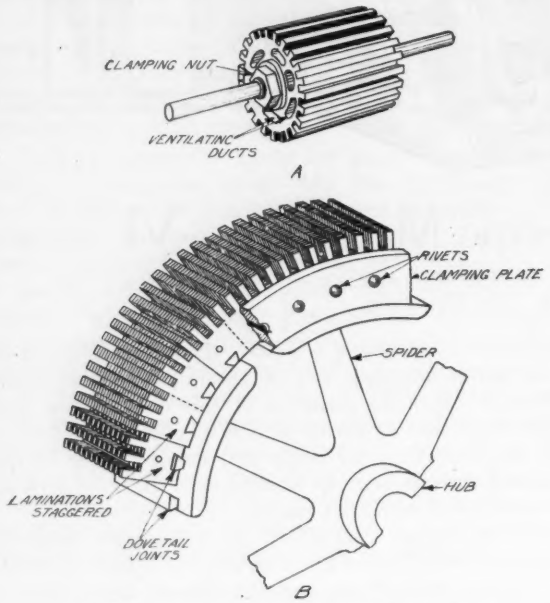
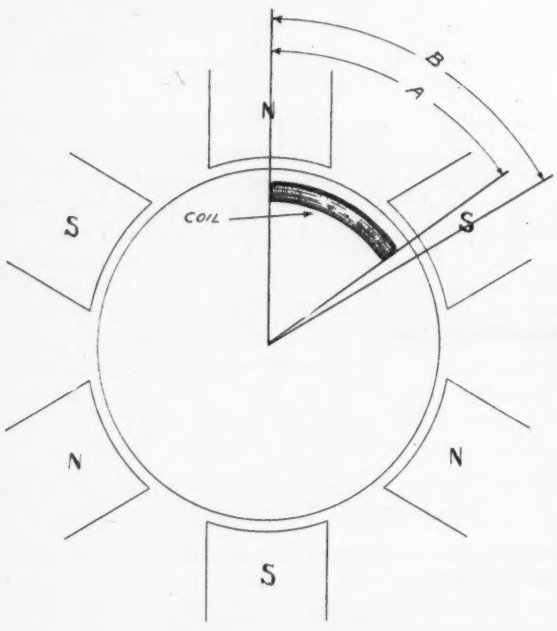


FIG. 36. TYPICAL DRUM ARMATURE CORES

ing the weight of the structure, but also assisting in providing more satisfactory ventilation. To facilitate manufacture, handling and assembly sectional lamina-



A = WINDING PITCH
B = ANGULAR POLE PITCH

FIG. 37. ILLUSTRATING WINDING PITCH AND ANGULAR POLE PITCH

tions are used on the large armatures, which also are provided with ducts allowing the passage of air from the interior to the exterior of the armature core.

PURPOSE OF LAMINATIONS

WHERE a piece of iron such as the armature of a dynamo is rapidly alternately magnetized and demagnetized, an electromotive force is induced which sets up the flow of currents generally referred to as eddy currents. The flow of such currents in the case of an armature is in a direction parallel to the axis of the shaft. Naturally as may be expected, the existence of eddy currents is accompanied by considerable heating and in order to reduce the eddy currents, and the detrimental effects of their presence, the laminated form of structure is employed. Thickness of lamination used is de-

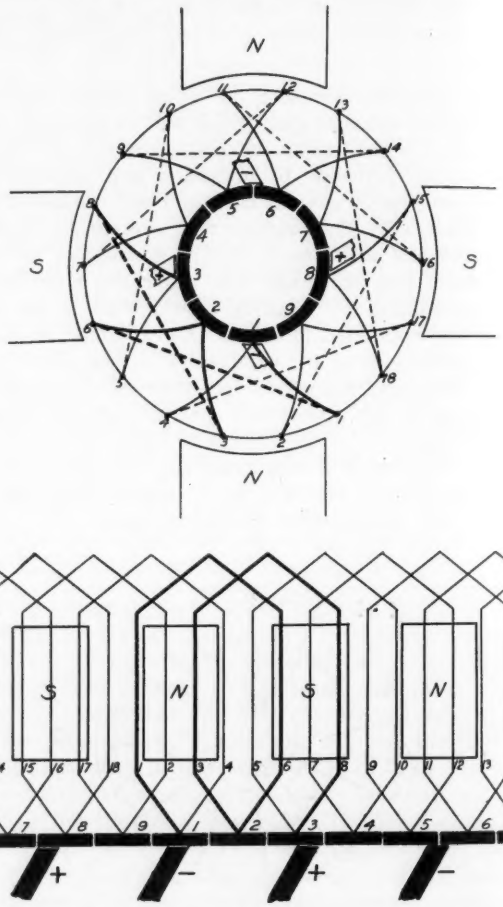


FIG. 38. SCHEME OF CONNECTIONS OF A LAP-WOUND ARMATURE

pendent upon the number of magnetic reversals. In direct-current machines of moderate size, the armature core is subject to from 15 to 60 or more cycles per second, and the laminations are usually made from 0.020 to 0.035 in. in thickness.

DRUM WINDINGS

ALTHOUGH the armature core has for simplicity been omitted, Fig. 19, page 594 of the July 1 issue illustrates the elementary type of drum armature used in connection with a bi-polar machine, the wire being wound lengthwise (parallel to the shaft) and diametrically across the ends. In a drum armature for a multipolar machine, the wire is wound lengthwise on the outside

surface of the core and across the ends, along chords of nearly 90 deg. for a 4-pole dynamo, along chords of nearly 60 deg. for a 6-pole field, and along chords of nearly 45 deg. for an 8-pole field. The approximate spacing between conductors of a given coil is equal to 360 divided by p, where p is the number of field poles.

Spacing of an armature coil in the case of a 6-pole machine is as shown in Fig. 37. Angle A is called the angular pitch or spread of the coil, or the winding pitch, while angle B is the angular pole pitch.

In Figs. 38 and 39 are shown two types of drum winding, the lap and the wave respectively. There is no essential difference between these two schemes in the case of a bipolar dynamo; but in the case of multipolar machines, the lap winding always provides as many paths between the brushes, as there are field poles, while with the simple wave winding, there are always two paths between the brushes regardless of the number of field poles.

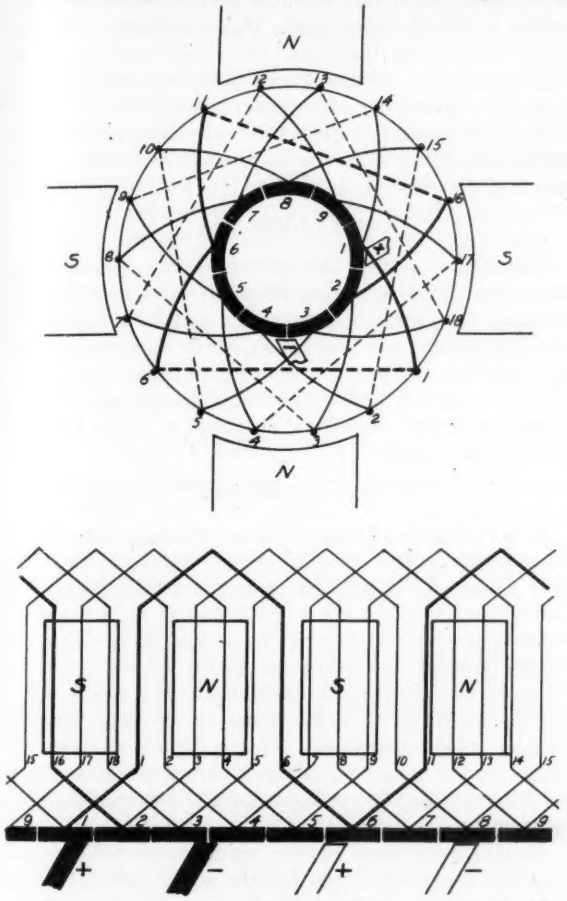


FIG. 39. SCHEME OF CONNECTIONS OF A WAVE-WOUND ARMATURE

Reviewing the fundamental equation of the dynamo as given on page 323 of the April 1 issue, we find the induced electromotive force equal to $FZN \div (100{,}000{,}000 \times 60)$ where F is the total number of magnetic lines of force cut, Z the number of conductors in series, and N the number of revolutions made per minute by each conductor.

This equation was based on the assumption that there is but one electrical path in parallel between the brushes, which is, however, not the case in commercial machines. If, then, we represent the number of such electrical paths by p′ and let F be equal to the product of p and F″ where p is the number of pairs of field poles and F″ the flux which enters the armature from each north pole of the field magnet, the above equation may be made to read $p\,F''ZN \div (p' \times 100{,}000{,}000 \times 60)$.

If, therefore, as stated above, in a wave wound armature there are always two paths between the brushes regardless of the number of field poles, and in the case of a lap wound armature there are as many paths between the brushes as there are pole pieces, it is evident that a multipolar machine having a wave-wound armature ($p' = 2$) will provide a greater electromotive force than the same machine with a lap wound armature in which $p' = p$. This under the assumption that the number of armature inductors remain the same in each case.

The armature shown in Fig. 38 and equipped with the lap form of winding is as may be seen fitted with

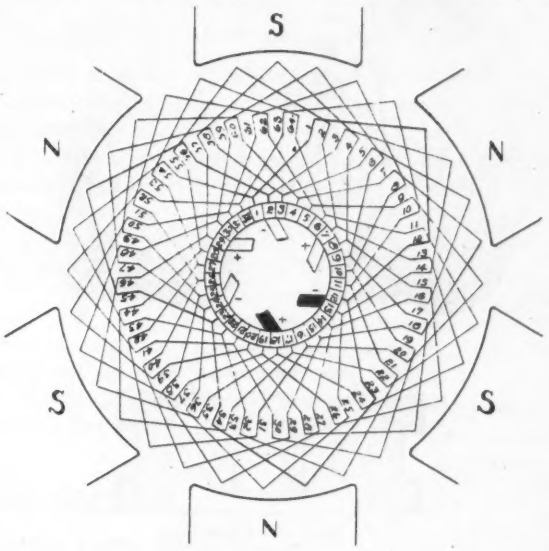


FIG. 40. TYPICAL 6-POLE DUPLEX WAVE-WOUND ARMATURE

18 active inductors and 9 commutator bars, or as each winding element consists of two inductors there are as many winding elements as there are commutator segments. Starting at commutator bar 1 and tracing the course of a single element, we find this bar connected to element 1, the continuation of which connects with segment 2. This also connects with inductors 3 and 8 the latter as indicated joined to segment 3, thus illustrating the lapping of the various elements one on the other.

It will be noted that inductor 1 is connected to inductor 6; 3 is connected to 8; 5 to 10 and so on, thus indicating an interval of five between the various inductors at the rear end of the armature. In other words, this interval or, as it is more properly termed, back pitch, is equal to five. Similarly inductor 1 is connected to segment 1 as is also inductor 4; inductors 5 and 8 are connected to segment 3 and inductors 7 and 10 to segment 4 in each case an interval of three, that is the difference between the numbers of the inductors as 1-4; 5-8; and 7-10. This interval is termed the front pitch.

Where, as in Fig. 38 the leads of each winding element connect with adjacent commutator segments, the winding is called a simple or simplex lap winding while if these leads are connected not to adjacent commutator segments, but to every other segment, the winding is referred to as a duplex lap winding. With the leads connected to every third commutator segment, the winding is said to be of the triplex lap form. The interval between the terminals of a winding element is referred to as the commutator pitch, which, in the case of the simplex winding illustrated in Fig. 38, is 1; in a duplex winding, it would be, plus or minus 2, and in a triplex winding, plus or minus 3.

A typical wave winding is shown in Fig. 39. Tracing this diagram, we find, as in the case of the lap winding, Fig. 38, inductor 1 connected to commutator segment 1 and its continuation, inductor 6 to segment 6, the scheme being such, however, as to produce a zigzag, or as its name implies, a wave winding. Here, front and

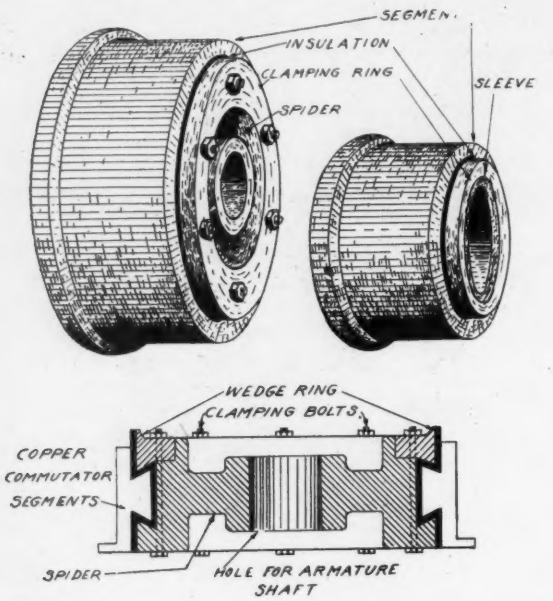


FIG. 41. TYPICAL COMMUTATOR ASSEMBLIES AND DETAILS

back pitches are each five, as is also the commutator pitch. Any wave winding which leads from a given commutator segment to an adjacent segment after passing through $p \div 2$ winding elements where p is the number of field poles for which the winding is made, is called a simplex or single wave winding. Where $p \div 2$ winding elements lead from one commutator segment to the second adjacent, the winding is duplex and where to the third following segment, the winding is called triplex.

With duplex windings, each brush must be of such a width as at all times to bridge two commutator segments, while in a triplex winding each brush must bridge at least three commutator segments.

Multiplex windings are seldom used in modern machines; duplex windings are found only in the larger sized generators.

In the case of a simplex lap wound armature used in connection with a bipolar field, it is seen that there are two paths in parallel, between the positive and negative brushes; with a four-pole machine, there are four such paths; with a six-pole machine, six, and so on. Dividing the total number of inductors by the number of poles will therefore give the number of inductors in series in each path.

On the other hand, we find in the simplex-wave wound armature two paths in parallel between positive and negative brushes, irrespective of the number of poles and number of brush sets. Therefore, the number of inductors in series between positive and negative brushes in wave windings is always equal to one-half of the total number of inductors. Comparing lap and wave windings in which the total number of inductors remains the same, we find that the former gives considerably more paths between the brushes, and fewer inductors in series in each path, than the latter. The use of lap winding is, therefore, frequently referred to as parallel grouping of inductors, while the wave type is many times called the series grouping of inductors.

Simplex lap and simplex wave windings are also frequently termed multiple circuit and two-circuit windings, respectively.

Brushes Required

In order to permit the delivery of the greatest current output with minimum internal losses in simple or multiplex lap windings, as many brush sets must be provided as there are pole pieces, while with the simplex wave winding two brush sets, one positive and one negative, are necessary and sufficient; although any number of sets up to and including as many as there are pole pieces, may be used.

The Commutator

The function of this device has already been treated and deserves no further discussion except as to its structural details. Forged copper segments thoroughly insulated one from the other by means of mica segments are mounted on and secured by means of an iron supporting member consisting as shown in Fig. 41 of a sleeve in the case of small machines, and a spider in the case of larger ones, which carry wedge rings held in place by clamping rings. Heavy layers of mica arranged in the manner indicated prevent electrical contact between the copper segments and the iron supporting member.

Slotted projections on the inside ends of the copper segments provided means for the soldering of the coil leads.

Brushes

Except for special services, so-called carbon brushes are used almost exclusively on present-day dynamo machines. And while, as a rule, brush manufacturers refrain from making public their work, evidently preferring to keep the processes as trade secrets, it is known that they are generally made up of two or more of the four elements: lampblack, finely ground petroleum coke, graphite and some kind of tar or petroleum pitch to serve as a binder.

Each of these ingredients produces a different effect, and a suitable proportion seems necessary and varies with the use of the brush. A brush made mostly of lampblack, with a suitable binder would be dense and

hard, but of poor conductivity and would cut copper badly. One made mostly of graphite is usually too soft and on ungrooved commutators wears away too rapidly. It can readily be appreciated that for some special purposes, it may be well to incorporate hard polishing material into a brush as where much mica must be cut, and when high conductivity, and therefore much graphite, is desired.

Unequal wear of copper and mica commutator segments requires at least some abrasive to keep the mica flush with the copper and to retain a polished commutator. This is secured by means of impurities such as mica, silica, iron oxide, carborundum and quartz, which are generally present, the last two being the most abrasive. With like amount of impurities, soft brushes, due to their tendencies to wear more readily, are found the more abrasive.

In general, the brush should possess such characteristics as will enable it to carry the maximum current to be transmitted by it. This maximum current consists of two factors, for either direct current or alternating current use, viz: (a) The kilowatt load or working current of the machine and (b) in direct-current service, the short-circuiting current between the bars being commutated, and in alternating-current service, the magnetizing currents due to power factors above or below unity.

Brushes should be self-lubricating and when made of copper can carry 35 w. per square inch as for example 35 amp. per square inch with a drop of 1 v. at the point of contact.

Brush Tension

If the pressure of the various brushes against the commutator is not equal the load will not be divided equally among them, and overheating will occur with detrimental results. Brush tension may range from a minimum of 2 lb. per square inch to 5 lb. per square inch depending upon the characteristics of the brush, the speed of the commutator and the mechanical condition of the commutator. Generally, however, tensions of 2.5 to 3.5 lb. per square inch are used on direct current generator commutators.

Number of watts loss in any given machine due to brush friction may be readily determined by means of the following formula:

$$W = \frac{A \times P \times F \times S}{44.26}$$

Where W is the loss in watts, A is the total area of brush contact in square inches, P is the brush pressure in pounds per square inch, F is the coefficient of friction of the brush, S is the peripheral speed of the commutator in feet per minute and 44.26 is the number of foot-pounds equivalent to one watt.

The coefficient of friction of a carbon brush is the ratio of the frictional pull of the commutator on the brush to the pressure of the brush on the commutator and varies from a little above zero to over 0.9.

Questions and Problems for Review

Make a sketch of a typical Gramme ring-wound armature and explain in detail how commutation is accomplished.

2. What are eddy currents and by what form of armature construction are their effects reduced to a minimum?

3. Make a sketch of (*a*) a typical lap armature winding and (*b*) of a typical wave winding.

4. The total brush contact surface on a 4-pole generator is 6 sq. in., the average brush pressure is 2½ lb. per square inch, the coefficient of friction is 0.7 and the peripheral speed of the commutator is equal to 750 ft. per minute. Calculate the number of watts lost due to brush friction.

Electric Furnaces*

Description and Characteristics of Types Employed

THE last few years have shown a great increase in the number of electric furnaces in operation throughout the country, due to their superiority over former methods of production along the following lines: (1) Better and cheaper product; (2) adaptability; (3) simplicity; (4) comparatively low installation and maintenance costs; (5) effective and simple control; and (6) safety.

Electric furnaces in most general commercial use are of the arc type, resistance type or a combination of the two, and in general are divided into two classes.

1. For smelting, stationary type, rated on 24-hr. continuous output.
2. For melting and refining, tilting type, rated in holding capacity per heat.

A metallurgist and manager of a large reduction company gives the following figures as to power consumed by electric furnaces for several different products:

Products	Kw.-hr. per Ton
Steel	600 to 800
80 per cent Ferro-Manganese	3500 to 5000
Ferro-Silicon Alloy	7000 to 9000
Tungsten or Molybdenum	8000 to 10,000
Metallic Chrome (60 per cent to 70 per cent alloy)	10,000 to 14,000

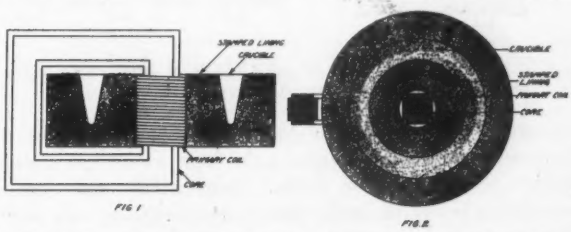


FIG. 1. VERTICAL SECTION OF AN INDUCTION FURNACE
FIG. 2. CROSS SECTION IN HORIZONTAL PLANE OF SINGLE-RING INDUCTION FURNACE

In 1918 there was an increase in the number of electric steel furnaces of 54, making the total in this country 287.

* Abstract of Report of Committee on Electrical Apparatus read before the N. E. L. A. at its 42nd Convention, May 19-22, 1919.

At the present time, the majority of the steel furnaces installed range from one to six tons in capacity of metal, the installed transformer capacity for furnaces ranging from 300 to 1500 kv.a. Several furnaces of large size are in operation, however, the largest being of about 25 tons holding capacity, with transformer equipment of from 3500 to 4000 kv.a. capacity.

Practically all steel furnaces now being installed are of either 3-phase or 2-phase type and can consequently be operated from a 3-phase system without causing serious unbalanced load conditions. There are also a

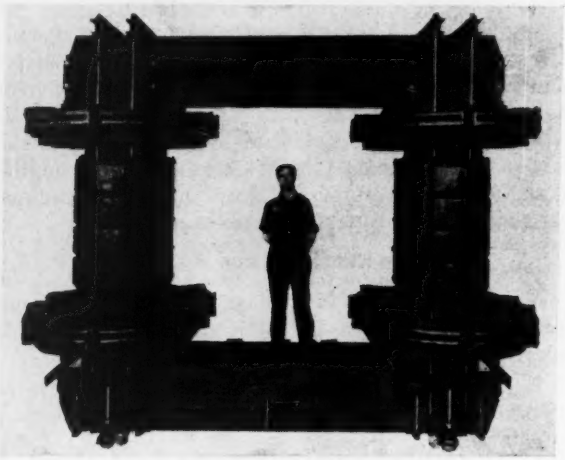


FIG. 3. CORE AND COILS OF A TYPICAL INDUCTION FURNACE

number of single-phase furnaces still being used. All electric furnaces now used in this country in the commercial production of steel are of the arc type and consequently operate at a power factor as a rule well above 80 per cent. In fact, there are several 1500-kv.a. furnaces operated on 60-cycle circuits at approximately 93 per cent. While a high power factor is of course desirable, it must be remembered that to obtain a high power factor we must have a low reactance circuit, and that consequently the momentary surges which are

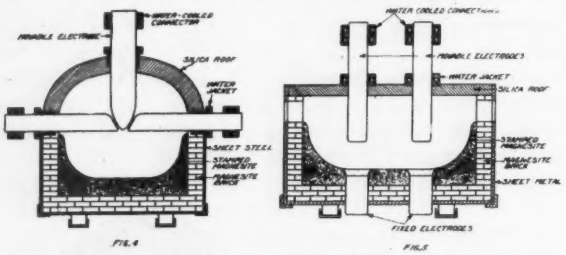


FIG. 4. CROSS SECTION OF RENNERFELT ARC FURNACE
FIG. 5. CROSS SECTION OF NATUSIUS ARC FURNACE

bound to occur in any steel-melting furnaces, will reach a somewhat higher value in a furnace which has a very high operating power factor than in one that has a somewhat lower normal power factor. Since, as a rule, the greater portion of the reactance in a furnace circuit lies in the busbars and cables, the percentage reactance will vary with the arc voltage of the furnace and the kv.a. capacity of the transformer. In some furnaces which use rather high arc voltages, either during a portion or the whole of the operating cycle, an external reactance coil is connected in the circuit during that portion of the cycle for which the high voltage is used. It is seldom, except on small furnaces, that the value of the momentary current surges which occur will exceed 2½ to 3 times the normal current value. Most furnaces are now equipped with regulators which automatically maintain the power input at the desired value, except for the momentary fluctuations which occur when a piece

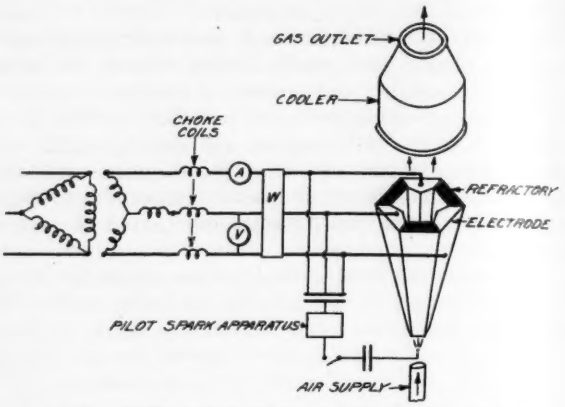


FIG. 6. THREE-PHASE NITROGEN FIXATION FURNACE

of metal falls against the electrode or something of that sort. These regulators have been developed to a high degree of perfection and give excellent results.

Electric furnace transformers are practically always special, inasmuch as the voltages required by the furnaces are not the same as those for ordinary low-voltage power service.

Ferro-alloy and calcium carbide furnaces are of the arm type, usually 3-phase, and vary anywhere from 300 to 20,000 kv.a. of transformer capacity installed per fur-

FIG. 7. INSIDE OF SECTION OF ELECTRICALLY-HEATED GUN FURNACE

nace. Probably the largest single furnace installation which was put into operation in 1918 is the calcium carbide plant erected by the Government at Muscle Shoals, Ala., in connection with the nitrate development. In this plant 12 furnaces are installed, each having approximately 8000 kv.a. in transformer capacity. A ferro-manganese plant consisting of five 5500-kv.a. transformers was also installed in Montana.

A considerable number of electric brass-melting furnaces were installed during 1918, the majority of these being of small capacity, requiring about 200 to 300 kv.a. in transformer capacity. Some of these are of the arc type, some of the resistance type, some 3-phase and some single-phase. The majority of them are single-

phase. Several installations of small induction type brass melting furnaces are also being made. These as a rule require approximately 70 per cent power factor. The installation usually consists of quite a number of these small units, so that they may be distributed on the various phases of a 3-phase system, constituting practically a balanced load.

The induction or resistance furnace draws a steady load, free from the surges which are inherent in an arc furnace. This type of furnace has not been applied with any success to steel making in this country, although a good deal of experimental work has been carried on. However, if the difficulties that have been experienced can be overcome, prospects are that in the future the induction furnace may be used extensively for steel melting.

Figures 1, 2 and 3 show principle of operation and construction of an induction furnace, in which heat is generated by passing current through the charge of metal. A ring shaped hearth is built around core and primary windings, which, when filled with metal, forms the secondary of the transformer.

The various types of furnaces developed have somewhat different characteristics, consisting principally in the location of electrodes and electrical connections. Those favoring bottom electrodes claim in general that their use prevents chilling of metal and imparts motion to the metal which assists in melting and refining.

The table gives a brief description and a comparison of types of smelting and refining furnaces in more or less general use.

BRIEF DESCRIPTION AND A COMPARISON OF TYPES OF SMELTING AND REFINING FURNACES

Make.	Power Supply.	Electrodes.	Number and Sizes in Service.	General Description and Special Features.
Heroult	Three phase, with H. T. transformer windings in Y for starting arc and Delta for normal operation.	Electrodes all above charge.	Many in Sizes from one ton up.	Provided with automatic controlling equipment for keeping current balanced in three phases. Combined reactance of transformer and secondary loads of such value as to limit short circuit current to 229% of full load current. (See Fig. 50.)
Girod	Three-phase Y, with one leg reversed.	Two or more upper and one bottom.	1-3 electrode, 10-ton Transformers rated 700 kv-a., with taps for 65 and 80 v.	Transformers connected in Y with one leg reversed, practically same as three single-phase furnaces. In one case all current passes through bottom electrode. High reactance gives practically constant current characteristics.
Snyder	Two-phase, three-wire connection. Standard type transformer. (Originally built for single phase.)	Two top and one bottom electrode.	Several in smaller sizes. Three ton uses two 600-kv-a. Scott connected 11000-10370/125-250 v.	Voltage normally 220 open circuit, with external or internal reactance to give 160 at full load. Usually used as straight melting furnace.
Gronwell	Two-phase, three-wire....	Four upper and one bottom electrode (in 5-ton and over).	Several large furnaces..	Somewhat similar to Girod, except that upper electrodes are connected to outside leads of two-phase three-wire connection. Four single-phase transformers are used, permitting a variety of electrical connections for best results.
Rennerfelt	Two-phase, three-wire....	One vertical and two horizontal upper electrodes or multiples for increased capacities.	Several up to 3 ton, 2-6 ton (requiring 1600 kw. each, with 6 electrodes.)	Two horizontal side electrodes have automatic control. The two arcs between side and middle electrode combine to blow down in a blast of intense heat in the charge. External reactance in circuit with each electrode. (See Fig. 51.)
Nathusius	Three-phase, three-wire..	Three upper and three lower.	.....	By means of auto transformer connections between upper and lower electrodes and bath operator can heat top or bottom of charge independently or at same time, as desired, thus accelerating melting and refining processes by thoroughly mixing the metal and keeping the charge in motion as much as possible. (See Fig. 52.)
Greaves-Ethells.	Three-phase, three-wire..	Four or more upper movable. Lining constitutes bottom electrode.	Several three and six ton in England.	Uses three-phase power, three or six transformers connected in modified Y.
Booth-Hall	Two-phase, three-wire....	Two upper and one bottom, with auxiliary upper.	Several smaller type....	Auxiliary upper electrode is virtually connected in multiple with bottom electrode, and is used for a short time during starting variation of voltage, sometimes obtained by interconnected switches on primary connections. (See Fig. 53.)
Ludlum	Three-phase, three-wire..	Three upper or multiple, in larger capacities.	Several five and ten ton..	Power from Delta-connected circuit In normal operation middle electrode is in contact with the charge, with practically all resultant voltage drop in outer electrodes.
Moore	Three-phase, four-wire...	Three upper.....	Several in smaller sizes.	Various transformer connections are used to give different electrical characteristics for different parts of heat cycle
Vom Baur	Two-phase, three-wire....	Three upper.....	Several soon to be in operation in this country.	Neutral connected to middle electrode, which is normally larger for the increased current

A report from one of the member companies gives the following power factor values for electric furnaces in service on their system, the figures given being obtained from measurements at the transformer primary:

One 1-ton Heroult Furnace—Power Factor approximately 87%.
Two 1-ton Rennerfelt Furnaces—Power Factor approximately 74%.
Three 1-ton *Snyder Furnaces—Power Factor approximately 43-50%.
One 3-ton *Snyder Furnace—Power Factor approximately 60%
One 3-ton Moore Furnace—Power Factor approximately 87%.
Two 5-ton Ludlum Furnaces—Power Factor approximately 78%.

*Single-phase type.

Experience of power stations supplying power to electric furnaces would indicate that this class of load is very acceptable, as the power factor is usually fairly high, though occasionally trouble is experienced, due to poor voltage regulation caused by heavy current surges through furnaces operating with too low reactance values.

Nitrogen Fixation Furnaces

This class of furnace differs from the smelting and refining furnace in that voltages of several thousand (5500—6600 at 25 or 60 cycles) are used at the arc. Older types were of single phase, necessitating a group

of three for balanced load. A new 3-phase, nitrogen fixation furnace has recently been developed which promises good results. It is claimed that the furnace operates at high power factor, and present sizes require up to 300 kw. of energy. Suitable reactances are used to limit current surges.

This class of furnace offers good opportunities for the sale of off-peak power, as furnace may be started and stopped at any time without affecting the character of the product. As the process consists in the formation of nitric oxide from the combination of nitrogen and oxygen at the electric arc, there are no metals to freeze when power is suddenly discontinued. Large amounts of power are usually consumed by an air nitrate factory, the average size requiring approximately 10,000 kw.

Many heat treating furnaces have been developed for shrinking and heat treatment of guns, shafts, blocks and similar pieces. This type of furnace uses heavy resistance ribbon wound back and forth on moulded brick insulators inside the cylinder wall. Electric current is circulated through ribbon to heat pieces inserted in the cylinder. Furnaces of this type are made either vertical or horizontal and may be of either of the following types:

1. Shrinking furnace designed for temperatures up to 1000 deg. F. and built in horizontal or vertical sections of standard size to give desired length or height. Usually hand control.

2. Heat treating furnace designed for temperatures up to 1600 deg. F. Generally similar in construction in shrinking furnaces, except designed for higher temperature. Usually automatically regulated.

A great many of both types of heat-treating furnaces have been installed throughout the country during the past two years and the excellent power factor and load factor of a group of such furnaces make a very desirable load. Power required—from 35 to 500 kv.a. for various furnace sizes.

Industrial Safety---II

Plant Conditions, Arrangement, Order and Lighting in and Around Industrial Plants.* By C. W. Price

IN going through some plants, the visitor receives a strong impression that "this is a safe plant—everything that can be done for safety has been done here." Perhaps at the very entrance to the plant there is a "safety bump" in the roadway, to discourage speeding around a dangerous corner. Dangerous railroad crossings have been eliminated or well guarded; switch frogs are blocked; there are no water pipes or other "trippers" projecting a few inches above ground; roadways and walkways are well drained, and kept free from slippery places in winter. Within the building, wide aisles are found; machines are so placed that they receive the maximum of natural light; artificial lighting is adequate and of uniform quality; safe working space is provided around each machine and is kept clear of materials and tools; floors are in good repair and are not cluttered with rubbish or excessive dirt. Surplus materials and equipment, both indoors and out, are in orderly piles, easy to examine or remove.

If conditions like these impress the casual visitor, how great is their effect upon the men working in the plant! In such a plant it is comparatively easy to secure the workmen's co-operation in preventing accidents. In a plant bristling with danger points, the workmen look with suspicion on any educational safety campaign. It is useless to preach safety in a plant until at least the worst of the physical hazards have been corrected.

Plant Arrangement

WHEN a new plant or a new building or a new department is to be constructed or equipped, the work of the safety engineering begins with the first rough layout sketch. The arrangement of buildings, machinery, and equipment should be studied from the standpoint of safety, just as it is studied from the standpoint of handling material economically. This does not mean that the safety engineer will demand expensive changes. By examining the plans in advance, he may detect some hazard which would be quite costly to correct later, but which can be avoided without expense or inconvenience by altering the plans in advance. Examples are: Clearance between railroad tracks and buildings; clearance between end of crane bridge and wall or column; head room below overhead piping or ducts; location of valves, switches etc., where they can be reached safely and easily.

Places visited by only one or two men—such as the oiler or the lamp trimmer—are often neglected, and these workmen are subjected to danger. A permanent runway, with railing, reached by a substantial fixed ladder or stairway, will often pay for itself by cutting down the time required for these tasks.

In existing buildings, some of these hazards can be corrected without difficulty and others can be reduced by the use of guard-rails or other devices. Whenever an accident or a near-accident occurs, even though it was due largely to carelessness, ask yourself, "Could it have been prevented by any improvement in physical conditions?" If so, be sure that similar conditions are avoided in the future.

Order

MORE accidents result from men slipping or stumbling than from any other cause, and the aggregate time lost is large. Such accidents can be prevented only by "good housekeeping," both within the buildings and in the yard.

In most departments it is practicable to establish permanent aisles or passageways leading down the center of the shop, with other aisles running across, and passageways wherever workmen must go. The main aisles, at least, should be marked off with lines of white paint on the floor, about 2 in. wide, renewed as soon as they become indistinct; piling material or leaving equipment or tools within these lines should be strictly prohibited. Loose material should also be kept out of the spaces around machines, especially small pieces of pipe and similar objects which roll when stepped on.

*Abstract of lecture delivered before the Schools for Safety Engineers.

While disorder is often charged to carelessness of workmen, the real reason frequently is lack of proper equipment.

For storing small parts, such as gear wheels, racks can often be designed which will prevent piles falling over.

Before asking workmen to be orderly, it is necessary also to remove or guard all fixed obstacles which men may fall over or bump into, such as projecting pipes and valves, wires, and holes or rough places in floors.

Lighting

Insufficient and improper lighting causes, or helps to cause, over 20 per cent of all accidents; it also impairs vision and decreases efficiency.

In modern installations, the unit usually adopted for general illumination is the gas-filled tungsten lamp, and for individual machine lighting the vacuum tungsten lamp. These two types together cover a range of sizes from 10 to 1000 watts, and are thus convenient for every condition. These lamps consume one watt, or less, per candle power, as compared with 3½ watts per candle power for the old style carbon filament lamp. The color of the light rays is pleasing; the light from a blue-bulb gas-filled tungsten lamp resembles sunlight. The average life of the tungsten lamp is 1000 hr.

Mercury vapor lamps and mantle gas lamps are also frequently used and give good service under proper conditions.

The rated voltage of the lamp should be the same as the voltage of circuit at the lamp. Where the voltage of the circuit is 4½ per cent in excess of the lamp voltage, the life of the lamp is decreased 45 per cent; if the circuit voltage is 4½ per cent less, the candle power is reduced 15 per cent.

More than half of the light from the filament of a gas-filled tungsten lamp proceeds horizontally or upward and hence (except for some reflections from light ceilings and walls) is not useful in lighting the work. The purpose of a reflector is to throw the light downward on the work and keep it from shining into the eyes of the workmen. The deep-bowl reflector is widely used both for general illumination of shops and for individual machine and bench lighting. Reflectors of the shallow-bowl type distribute the light somewhat more efficiently and are good for overhead use, provided the reflector extends below the filament a distance equal to one-fourth the radius of the reflector mouth.

White porcelain-enameled steel reflectors are inexpensive, strong, resist fumes and moisture, and are easily cleaned. Where reflectors are kept clean—and this means cleaning them at least once each week—illumination is increased at least 25 per cent.

In ordinary shop rooms, without gas or smoke, 100-watt gas-filled tungsten lamps are often used, hung 10 ft. above the floor. For storage spaces, use not less than one 100-watt lamp for each 400 sq. ft. of floor area; for rough manufacturing, rough machining, rough assembling, rough bench work, use one 100-watt lamp for each 170 sq. ft.; for fine manufacturing, such as fine lathe work, pattern and tool making, use one 100-watt lamp for each 100 sq. ft. The lamps need not be arranged regularly unless a uniform illumination of floor is necessary. They should be so placed as to give the best light for individual machines or benches, and to avoid shadows from beams, columns, and other objects, as well as from the workman's body. Use no local lamps except in special cases.

If the ceiling is high enough, a more economical layout can often be secured by using 150 or 200-watt lamps, mounted higher, and spaced farther apart.

In foundries, forge shops, and steel mills use small lamps on low ceilings and large lamps on high ceilings. If there is no crane to interfere, use 200-watt lamps 20 ft. above the floor. Space the lamps uniformly over the room. Use not less than:

1	200-watt lamp	for each	325 sq. ft. of floor area
1	300-watt lamp	for each	500 sq. ft. of floor area
1	400-watt lamp	for each	700 sq. ft. of floor area
1	500-watt lamp	for each	850 sq. ft. of floor area
1	750-watt lamp	for each	1225 sq. ft. of floor area
1	1000-watt lamp	for each	1700 sq. ft. of floor area

If there is much smoke or dust in the air, decrease these areas by 1/3 or ½.

If local lights for individual machines and benches are absolutely necessary, use 25, 40, or 50-watt tungsten lamps with deep-bowl reflectors. These should be so attached or hung that a maximum of light reaches the tool, the light is completely concealed from the eyes of the operator, and shadows are avoided. On such machines as punch and drill presses, where operators sit close to machines, the light should be centered over the space between operator and machine. The amount of light should be sufficient to prevent eye strain and enable the operator to do efficient work. On some machines it is advisable to install an adjustable fixture so the operator can direct the light to the exact position desired. The use of rigid fixtures reduces the breakage of lamps.

Where the ceiling and upper part of the walls of a plant are kept properly whitened with either whitewash or cold-water paint, both natural and artificial light are greatly improved. The lower portion of walls may be darker to rest the eyes.

Keeping the windows clean will increase the natural light by at least 25 per cent. In most plants this item is sadly neglected. To avoid glare in workmen's eyes window shades or other means should be used where necessary. The use of prism glass will improve the natural lighting on machines near the center of the room.

Bookkeeping In the Steam Plant

By John Wallace

Application of bookkeeping to the steam plant seems rather an innovation; but it has been present in some plants, in one form or other, for a number of years. Large mills usually have a form of steam plant report which it is the duty of the chief engineer to make out correctly and turn over to his superiors at the end of the day, week or month. If this proceeding can be gone through in the large plant, what is to hinder it from becoming a standing feature in the small plant where it is sadly needed? A steam plant's economy or efficiency can be proved only by figures. One may know that a plant is efficient, but how can such be actually proved unless by detailed figures?

Any conscientious and enterprising engineer likes to accomplish just a little more and better work than

that of which his predecessor was capable. He will labor to his utmost to bring about this end by exercising unceasing vigilance in all matters and making every item count in his favor. At last, he is satisfied that there is nothing more to be done by way of improving the plant. He has cleaned his boilers thoroughly, covered his steam lines, utilized all exhaust to the benefit of his feed water, overhauled the valves and cylinders of his engines and what not; and he now feels that his mighty endeavors should be recognized by his employer in the form of a substantial increase in salary. All this is very right and proper. He broaches the subject to his employer, who at once wishes to know what he has accomplished. Where is the proof? The situation soon becomes one of "show me and I'll come across."

To be able to produce figures showing how you have saved coal, wages and other important items is what counts, not what you *say* you have saved him.

Figures are what pleases the boss. He is used to figuring in dollars and cents and naturally bases all successes and failures on those terms. What he wants and usually gets are results. If you can produce them and show him the whys and wherefores you need not worry concerning the increase in salary.

There are very few plants today without a recording pressure gage, a recording thermometer and a water flow meter of some make. Without these few instruments, any engineer works in the dark. With them he has the means of recording the performance of his steam plant both to his own and his employer's benefit. Needless to say modern equipment includes many other coal-saving devices too numerous to mention, with the help of which an engineer can materially increase the efficiency of his charge. But these devices are not installed in the majority of steam plants and so will not be considered.

CONVENIENT WEEKLY FORM

WEEK BEGINNING JULY 1919

	SUN	MON	TUES	WED	THUR	FRI	SAT	TOTAL
WEATHER					FAIR			
AV. OUTSIDE TEMP.					90°			
AV. FEED WATER TEMP.					205°			
ACTUAL WATER EVAP. LB.					316,167			
WATER EVAP. LB. F&A 212.					334,826			
EVAPORATION FACTOR					1.047			
HORSEPOWER DEVELOPED					398.8			
COAL BURNED LB.					32,000			
AV. GAGE PRESSURE					160			
NO. BOILERS IN USE					3			
RATED CAPACITY					450			
% RATED CAP. DEVELOPED					88.9			

Bookkeeping does not imply any complicated system offering employment to a score of pen-pushers, but instead, a simple yet efficient book, kept by the engineer himself and enabling him, at any moment, to issue to his employer a complete and correct statement of the steam plant's performance.

The book is preferably a 500-page day book. Any sizable blank book, purchasable for a nominal sum, will be perfectly suitable. All that is needed other than this is a brain and a pen or pencil. Ruled and classified as shown below, it should cover about all the items of steam plant operation found in ordinary industry and will, at a glance, reveal any abnormal features of the day's run. The accompanying form is an example.

At the end of the week the total of each item can be brought to the last column and these totals can be forwarded to another section of the book given over to weekly records. In still another section of the book record can be kept of all expenditures for material, all straight time or extras, all the oil received and consumed and anything else pertaining to the steam plant.

When such a record as this has been faithfully kept for a year or two, one can readily see, by referring to the figures, just what has been accomplished and whether today's or this week's run is generally better or worse than the same day or week of the previous year. If an engineer's heart is in his work he will try for a little better showing every day and soon learn to debate with himself upon ways and means of bringing this better showing about.

Let the engineer strive for high feed-water temperature and low evaporation consistent with the operation of the mill. Let him strive to keep his records conscientiously. Let him check his instruments occasionally to make sure he is in the right and when he approaches his employer let him carry his book with him. When the boss asks for proof this time the book, with its telltale figures of money saved, will clinch all arguments and doubts on his employer's part.

Five Principles of Effective Work

TO PLAN RIGHTLY YOU MUST KNOW—

(1) What work is to be done.
(2) How it is to be done.
(3) When it is to be done.
(4) Where it is to be done.

SCHEDULE

THE WORK MUST BE SCHEDULED. A SCHEDULE TO BE EFFECTIVE MUST BE—

(1) Definite.
(2) In harmony with other schedules.
(3) Difficult to accomplish; but—
(4) Possible to accomplish.
(5) Rigidly kept.

EXECUTION

IT MUST THEN BE EXECUTED—

(1) Skillfully.
(2) Accurately.
(3) Rapidly.
(4) Without unnecessary effort.
(5) Without unnecessary delay.

MEASURE

THE WORK ACCOMPLISHED MUST BE MEASURED—

(1) As to potentiality.
(2) As to your past records.
(3) As to the past record of others.
(4) As to quality.
(5) As to quantity.

REWARD

IF YOUR WORK IS ACCOMPLISHED EFFECTIVELY YOU SHOULD BE REWARDED WITH—

(1) Good working conditions.
(2) Health.
(3) Happiness.
(4) Self-development.
(5) Money.

The Diesel Engine---III*

LUBRICATION AND LUBRICATING OILS; IMPORTANT ADVANTAGES OF DIESEL ENGINES. BY HERBERT HAAS

WHEN the shaft and the connecting rods are not drilled for forced-feed lubrication, it is usual to provide each crank with a centrifugal oiling ring to deliver the oil to the crankpins. For this purpose the crankpins are drilled, the drilled passages receiving the oil from the rings and delivering it to the pin brasses. Oil-drip rings turned out of the solid material of the shaft confine the oil to the main bearings and lead it to the oil reservoirs in the crank pit. On the shaft is mounted the helical gear for engaging a like gear on the governor shaft and driving it, the gears dipping into the oil. A crankpin for driving the air compressor is part of the main shaft and is lubricated in the same manner as the other pins. The flywheel and the driving pulley are usually mounted on an enlarged part of the shaft, the extension of which is carried in an outboard bearing.

The main bearings for this type of shaft are either provided with an oiling ring or are constantly flooded with oil under pressure issuing from a pipe in the cover of each bearing. The surplus oil is collected in the crank pit and is filtered and cooled, and is returned to the bearing by a pressure oil pump. A circulating system of this kind insures positive lubrication of the main bearings, whereas oiling rings may possibly stick and through failure of lubrication cause the burning of a bearing.

Another system of lubrication, essential to high-speed and even medium-speed engines, and, on account of its satisfactory operation and sparing use of lubricants, favored increasingly for high-grade low-speed engines, is illustrated in Fig. 5. Drilled passages run from the middle of the main bearings diagonally through the middle of a journal and the webs of the cranks and issue in the middle of the crankpins. The connecting rod is hollow. Whenever these passages register, a part of the oil, aside from lubricating the main and the crankpin bearings, is forced through the hollow connecting rod and lubricates the piston-pin bearing. The oil is initially forced under pressure through the covers of the main bearings. In other engines the oil is supplied through the bottom of each main bearing, permitting a simple arrangement of the oil piping and obviating the necessity of breaking pipe connections when the bearing covers are removed. The surplus oil is collected in the crank pit, flows to a filter, through a cooler, and is returned to the bearings by a positive-pressure pump, driven direct from the main engine either by gearing or side cranks. Figure 6 illustrates such an oiling system.

The lubricating system last described effectively lubricates the piston-pin bearing, which is of particular importance, as its position inside the trunk piston and in close proximity to the piston head subjects it to heat by absorption and conduction, in addition to the severe duty it has to perform regularly in transmitting the high piston pressures. Engines using centrifugal oiling rings have a separate oil supply for the piston-pin.

In vertical engines one of the plungers of a forced-feed oil pump used for cylinder lubrication delivers oil through a feed in the cylinder frame and the liner to a vertical groove in the piston. This groove is above the piston pin and is connected with drilled passages in the piston and the piston-pin, and through these passages the oil is fed to the pin bearings.

In horizontal engines with trunk pistons the feeding of the piston-pin bearing is simple. An inclined oil-feed pipe provided externally with a wiper is fastened to the inner wall of the trunk piston. With every stroke of the piston a measured supply of oil furnished by a separate pump plunger is carried to the piston-pin bearing.

The main bearings are usually semicylindrical, babbited, cast-steel shells, carried by carefully machined seats cast integral with the bedplate, the shells being held down by their covers. They have no wedge adjustment, but rest rigidly in their seats. In practice it has been found difficult to keep numerous adjustable bearings in perfect alinement, and inequalities in adjustment of the different bearings have frequently led to broken shafts. With the bearings once carefully machined and alined in the shop, the wear over all bearings is uniform and light in high-grade engines, in which the bearings are flooded with oil from a forced-feed system, uniform bearing pressure being insured through an equally proportioned supply of fuel oil furnished to each cylinder. Thin brass shims are placed between the bearing shells; to take up wear a shim is removed from each side of each bearing. By raising the shaft slightly, the shells can be rolled out for rebabbiting. The seats are chalked, and any inequality is apparent on the carefully machined arbor. Any roughness is then removed by scraping.

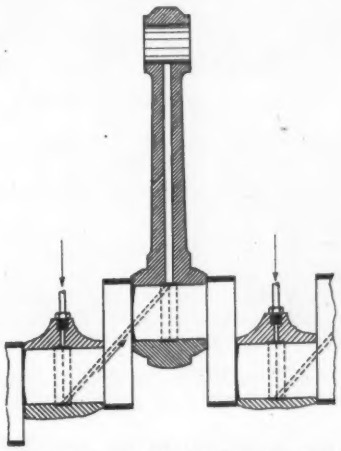


FIG. 5. SYSTEM OF LUBRICATION ESPECIALLY ADAPTED TO HIGH SPEED ENGINES

The connecting rod is forged of soft, low-carbon steel and has a hollow center in engines using forced-feed lubrication. Hollow rods are often used, especially in

* Abstract of Bulletin 156 of the Department of the Interior, Bureau of Mines.

small engines, to decrease weight. The crankpin end is usually provided with a marine head, the boxes of which are either lined with babbit or bronze, the head proper being of cast steel, and is bolted to the connecting rod. Brass shims are usually placed between the head and the rod to permit adjustment and insure the desired compression. The piston-pin end of the rod is usually slotted out of the solid to receive an adjustable box made of cast steel or cast iron lined with babbit and bronze. Adjustment is made either by shims held by adjusting screws or by wedges. The positive rigidity obtained with square shims and adjusting screws is usually given preference over the wedge adjustment. For large engines a marine head for the piston end is sometimes preferred as offering greater ease of adjustment; however, it offers no advantages over the closed head when it has to be removed. The piston and rod of either type are pulled through the top of the cylinder and the rod is removed by knocking out the piston-pin. In horizontal engines

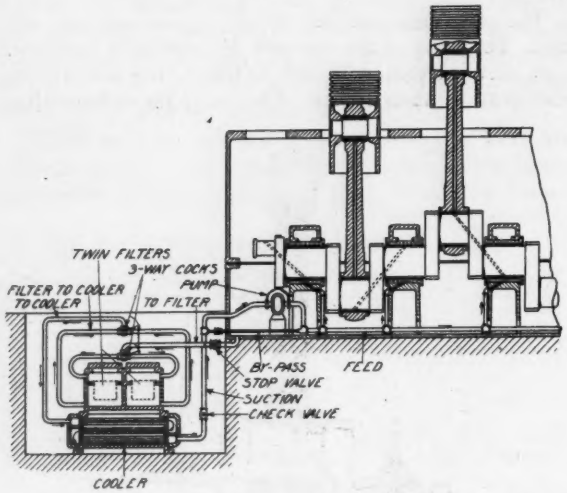


FIG. 6. LUBRICATING SYSTEM IN WHICH OIL IS SUPPLIED THROUGH THE BOTTOM OF EACH MAIN BEARING

the pistons are pulled out of the open bottom of the cylinder, so that the heads do not have to be removed, an advantageous arrangement. Some types of vertical engines are so built as to permit pulling the piston from the bottom of the cylinder.

Lubricating Oils for Diesel Engines

Two kinds of oils are used for the lubrication of Diesel engines—bearing oil and cylinder oil.

Bearing oil is used for the lubrication of the main, the crankpin, and the piston-pin bearings, and of the cam-shaft bearings, and for the oil baths into which the cams and the camshaft dip. A pure mineral oil will fill these requirements if it has a maximum viscosity of 7 deg. Engler at 50 deg. C., if it does not congeal at a temperature higher than —10 deg. C., and if it has a flash point of 180 to 200 deg. C. The oil should be entirely soluble in benzine, forming a clear solution without any residue; also, it should be entirely free from acids, resinous substances, and vegetable matter.

Cylinder oil is used for the lubrication of the working cylinders and the air-compressor cylinders. It should be stable at the relatively high temperatures of the piston and the cylinders of a Diesel engine, and should maintain the desired lubricating properties at these temperatures; it should not vaporize readily, nor should it decompose at a temperature lower than 300 deg. C.

A suitable cylinder oil should have a viscosity of 9 to 10 deg. Engler at 50 deg. C., and should flow at —5 deg. C. Its flash point should not be below 240 deg. C. It should be a pure mineral oil free from asphaltum and pitch and resinous substances, and should be completely soluble in benzine, leaving a clear solution without any residue. A piece of sheet brass covered for 24 hr. with the oil, at 100 deg. C., should remain perfectly bright and show no action by acids, nor should it be gummed by any substance. A thin layer of the oil spread on the sheet of brass should contain no solid particles perceptible to the sense of touch.

Even the best oils will become partly oxidized in the compressor and engine cylinders and form complex pitch-like substances and insoluble compounds, which absorb fine metal particles from the compressor cylinder or dust that is carried into the cylinder with the air. With good oils it takes many months to form such accretions, and their harmful effect can be entirely avoided by a periodical inspection and cleaning of the cylinders.

Cylinder oils should not be decomposed in the working cylinders nor the air-compressor cylinders, as decomposition permits the more volatile part of the oil to burn and form carbon, which covers the piston, causes the piston rings to stick, destroys the lubricating effect of the oil, and results in the scouring of the pistons and cylinders, and sometimes in the seizure of the pistons.

Users of Diesel engines can make no more serious mistake than to purchase a low-priced cylinder oil in an attempt at economy. A high-grade cylinder oil, sparingly used, will prove most economical as regards both the quantity of oil consumed, and the cost of engine upkeep. Oil analyses alone are insufficient to govern the selection of a desirable oil. The best way of testing the suitability of an oil is to note its performance in a Diesel-engine cylinder. The best guide in the purchase of lubricating oils is the recommendation of the engine builders, as their recommendation is usually based on the results of protracted tests of different lubricating oils.

Important Advantages of Diesel Engines

The high commercial value of the Diesel engine lies in its unsurpassed fuel economy and in its ability to burn low-priced liquid fuels with high boiling points. This great fuel economy is not confined merely to medium or large-sized units, for the smallest engine has nearly the same fuel economy as the largest. In this respect Diesel engines differ from steam engines, which become economical only in large sizes.

The Diesel engine possesses the further great advantage of being a self-contained prime mover, its only auxiliary being the air compressor, which in all high-grade engines is driven direct from the engine crank shaft, and is mounted on the engine frame. If directly connected to a direct-current generator or an alternator with exciter, it comprises with the switchboard equipment a complete electric generating station. Its space requirements are therefore small, and it can be placed in basements of buildings and hotels.

The small fuel requirements of the engine reduce to a minimum the space necessary for fuel storage, and as the engine uses liquid fuels, these can be piped by gravity from tank cars to the storage tanks below track level. A 10,000-gal. tank car will supply enough fuel to drive a 100-hp. engine at full load continuously, day and night, for more than two months. Noncondensing steam engines of the same size consume 4 to 6 lb. of coal or 2½ to 3 lb. of oil per effective horsepower-hour, or the equivalent of 340 to 500 tons of coal, or 200 to 250 tons of oil as compared with the 40 tons of oil used by the Diesel engine. The saving in storage space is evident.

Labor of unloading and storing coal, firing boilers, and removing the ashes, which may readily amount to one-quarter of the coal fired, is entirely eliminated in Diesel-engine plants. The absence of coal, ash, and smoke makes for cleanliness. The Diesel engine is noiseless and its exhaust is colorless and odorless, so that its operation meets all hygienic requirements.

The engine is in readiness for instant operation, and can take on full load from no load as quickly as the operator can make the different shifts, a matter of only 2 or 3 min. With the stopping of the engine no further fuel is consumed. In this respect the Diesel engine differs from heat engines in which the working fluid is generated outside of the engine in boilers for steam engines and in gas producers for suction-gas engines. The Diesel engine has no stand-by losses. Boiler or gas-producer losses in firing up, losses up the stack, losses in incompletely burned and clinkered coal, radiation and condensation losses, losses due to inefficient firing of boilers or their insufficient upkeep, or, in suction gas plants, losses due to inefficient producer operation, to afterburning caused by incorrect setting of the valves or timing of the ignition—these add considerably to the increased heat consumption of steam and gas engines at fractional loads. In this respect the Diesel engine differs from other prime movers in that its over-all fuel economy is not dependent upon the efficient operation of auxiliaries, or even on the skill of the operator, as its operation is largely an automatic thermodynamic process in the engine itself.

Reliability

With a correctly designed and efficiently built engine this economy will be maintained undiminished during the life of the engine, provided the engine receives proper care.

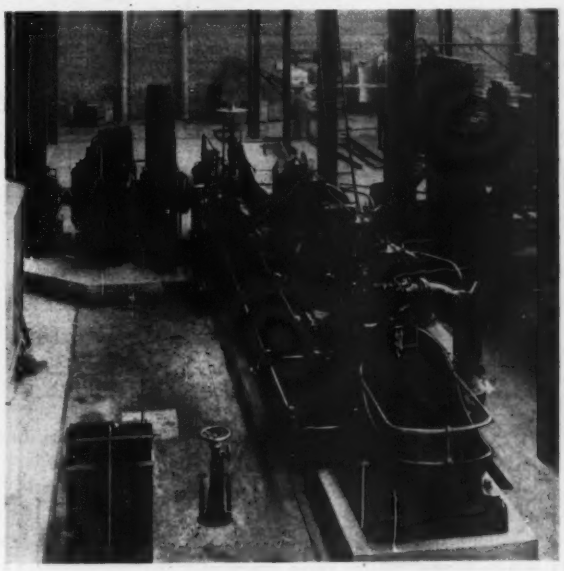
The claim of greater reliability for the steam engine is frequently made, because an engine supplied with steam from a boiler will continue to run even if piston or glands leak, or the valves are improperly set for operating economy, and no matter how wastefully the boiler may be operated; whereas the Diesel engine has to generate its own driving fluid in the engine cylinder, and if any part of the engine fails the engine must stop. However, the supposedly greater reliability of the steam engine is obtained at the expense of a greatly increased fuel consumption.

The Diesel engine has been developed to such a degree of perfection during the past decade that carefully built engines can be considered as being fully as reliable as steam equipment.

Low Power Cost With Natural Gas

Operating at the plant of the Chas. Boldt Co., of Huntington, W. Va., are three 550-hp. single tandem, double-acting gas engines which have shown an exceptional record for economy. These engines are located in a glass factory which operates continuously 24 hr. a day, and during their 5 yr. service, have been shut only at 6-week intervals for general inspection and changing igniters.

Each engine drives a direct-current generator at 150 r.p.m. and operates with natural gas having approximately 1000 B.t.u. per cubic foot. One of these units is shown in the accompanying view. In addition to the three 550-hp. engines, a 175-hp. duplex gas engine is provided to drive a 125-kw. generator.



GAS ENGINE GENERATING UNIT AT PLANT OF THE CHAS BOLDT CO.

In a report of the gas engine plant efficiency covering a period of one year, the following data was recorded:

Interest on investment	$ 3,540
Depreciation	3,000
Cylinder oil	846
Lubricating oil	174
Repairs	800
Labor	7,280
Natural gas consumed—52,000,000 cu. ft. at $0.09 per M.	4,680
	$20,520

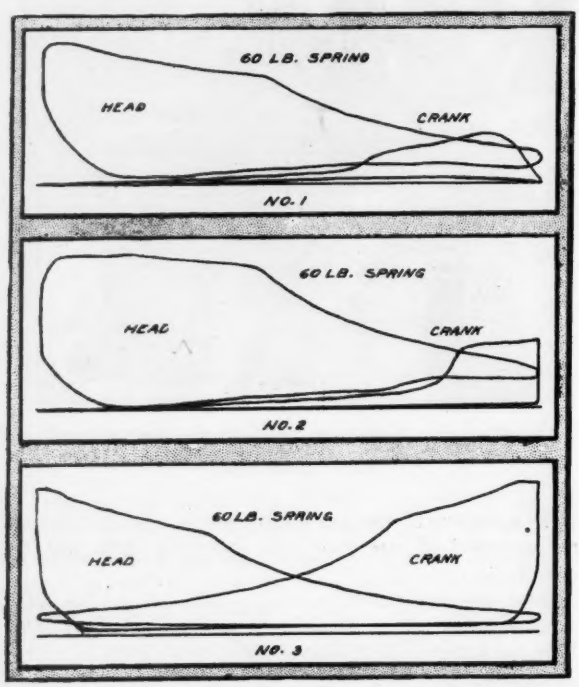
Producing a total of 4,576,500 kw.-hr., these units developed 1 kw. for each 11.36 cu. ft. of gas or at a cost of $0.0055 per kw.

On a steam-engine-indicator diagram the terminal pressure may be found by extending the expansion curve to the end of the diagram. The theoretical terminal pressure is found by dividing the pressure at cutoff by the ratio of expansion.

Broken Valve and Irregular Running

AN ENGINE of somewhat peculiar construction, was recently giving trouble. The engine was a 16 by 30 in. having gridiron valves, two admission valves on one side and two exhaust valves on the opposite side. They are operated by cams, on shafts driven by gears, and they all get their motion from a long shaft driven by a train of gears, from the crank shaft. The valves are adjustable on the valve stems.

An indicator was placed on the cylinder, and card No. 1 was taken. It showed the head end doing all the work, and a late steam admission and low pressure at the crank end. The engine had a throttling governor.



CARDS SHOWING PROGRESS IN VALVE REPAIR

The crank end steam valve was given a little more lead, and card No. 2 was taken. This showed some difference, and then attention was given to the crank and exhaust valve. The steam chest cover was removed, and the cause of trouble located. The exhaust valve had broken and part of it, about 3/5, had fallen down behind the other piece of valve, which being still attached to the valve stem still worked properly over two of the openings in the seat. The remainder of the openings being uncovered all the time, permitted the live steam to blow through continuously.

A new valve was made, placed in the engine and after a few adjustments card No. 3 was taken; full load. The fireman said that while he had a hard time previously to maintain the necessary pressure, he now had to watch to keep the boiler from blowing off.

My attention was once called to a case of a Corliss engine which suddenly developed a case of irregular running. It was belted to a short line shaft, and from this shaft a small generator, and some little light machinery were running. The voltage would rise and fall, the hand of the voltmeter traveling a stretch of 50 v.

At first it was thought the belts were slipping, but upon examination this was proven not to be the case. Then an indicator was applied to the cylinder, and it was found that one end was doing all the work. After the cutoff and valves were properly set, the engine ran as steady as it ever did. It was afterward found that the engineer, a new man, had an indicator on it and tried to improve the engine, but had only succeeded in making matters worse, until he had at last given up, and called in outside help.

TOM JONES.

Some Waterwheel Experiences

FIGURE 1 illustrates one of the waterwheels that supply power to a part of our plants. During periods of drought there is not enough water to develop any power in the wheels. At such times an engine delivers power onto the shaft at A, and the whole length of shafting transmits this to the driving pulley, B.

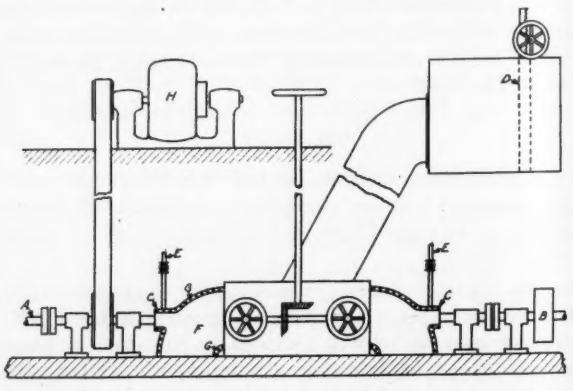


FIG. 1. ELEVATION OF WATERWHEEL INSTALLATION

To prevent the step bearings burning out, and to seal the gland bearings, C, a one-inch pipe, E, is connected ahead of the penstock opening into the forebay to enable the head gate, D, to be shut to save wheel leakage.

Owing to construction work by another party above us on the river, much grit entered the pipe, E, and

seriously damaged the shaft and babbit bearing, C. As it was not desirable to remove the shaft to the shop for repairs and the shaft could not be turned by the engine to advantage, the compound wound direct-current generator, H, on the floor above was considered.

We decided to convert it temporarily into a motor, doing it this way: Knowing that the correct speed of the machine, H, as a generator would be about 10 per cent less when run as a motor, and, as that speed would be too fast to use, an adjustable rheostat was made out of two barrels, as shown in Fig. 2.

The armature line running from the switch to the brush was opened and a fire door lining clamped to one end of the line, being allowed to lie on the bottom of the barrel. Two other linings were clamped to a piece of line and hung over the top of the barrel while resting on bottom of the second barrel. The third was clamped to the line, running to the brush. By raising and lowering 2, 3, as shown, the motor speed could be held where desired.

One-half of the quarter turn, F, was removed, also the bearing, which was sent to the shop to be rebabbited and bored out.

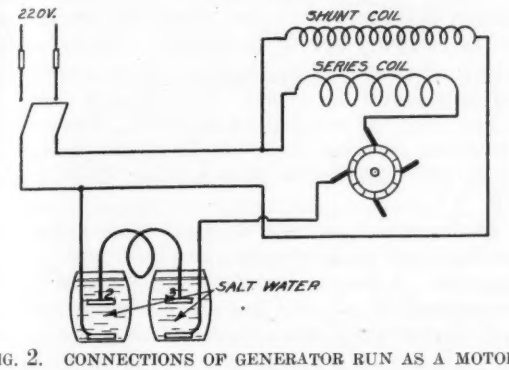


FIG. 2. CONNECTIONS OF GENERATOR RUN AS A MOTOR

The shaft was smoothed up by transferring a small lathe from the shop to the scene of action, after first taking off the feet.

A light chip was taken off the shaft with the tool carriage fed lengthwise of the bearing by hand, the motor in the meantime turning the shaft. The motor was then speeded up and the bearing smoothed with files. A liberal application of lead to the joint on the quarter turn made a tight joint when bolted up.

Great care should be taken to make tight joints here and to keep the shaft stuffing boxes tight, because any air leakage is into the wheel case, thus reducing the vacuum and hence the power of the wheel. How serious this leakage is may be seen from the following.

One of the wheels did not have a packing box, only a babbited sleeve. This wore and allowed air to enter, being plainly heard and, on closing the wheel gate, the water could be heard dropping rapidly.

The engine was run in conjunction with this wheel and a card taken, showing an engine load of 250 i. hp. Keeping conditions the same, the wheel gate was shut when the engine developed 450 hp.

We had a new bearing bracket made provided with a stuffing box. With the same load the engine indicated 240 hp. when the wheel was delivering power. When the gate was shut on the wheel, the engine load came up to 452 hp. As an engine horsepower per year is obtained at a cost of $30.50, it is seen that an investment of $200 for the bearing and labor was a good investment. As an experiment, the two clutches, one at each end of the wheel shaft, were pulled out, the wheel put up to full speed and the gate closed. The wheel ran 11 minutes before coming to a dead stop. RECEIVER.

That National License Law

JOHN HANNAN'S article, "National Engineers' License Law," in the Aug. 1 issue of Power Plant Engineering, brings out an idea that I have long had in mind and one that deserves the earnest consideration of every stationary engineer. The stationary engineer, as he remarks, receives the lowest pay and usually works the longest hours of any of the skilled trades. Why should this be so? One reason is that, excepting isolated instances, the engineer is not required to serve an adequate apprenticeship, as are all other trades, so that when an employer advertises for an engineer and a man applies for the position, saying that he is an engineer, the employer has to take his word for it. He puts him to work and if in a short time trouble develops in the plant which the engineer(?) cannot handle, the employer gets sore, fires him, hires another man and goes through the same routine, with practically the same result, and so on *ad infinitum*. Now if we had a National License Law similar to the one governing marine engineers, such a condition could not exist. The applicant would have to show his papers before he could be put to work and these papers would show that he had served the necessary time as an apprentice at his trade and therefore, within reasonable doubt, would be competent to handle the plant.

Let us consider for a moment, the case of the marine and the locomotive engineers. The marine engineer serves his time as a water-tender, oiler, etc., before he is allowed to take the examination, and this examination is conducted by the Government and therefore is a standard. When he has secured his certificate, he knows that he will secure work at good wages and conditions, because every man working in the engine-room aboard ship must be so licensed and the so-called engineer cannot "butt in." And the same thing is true of the locomotive engineer. He has to serve his time firing and at the end of the proper period of service, he, too, takes his examination, in this case conducted by the company, but, nevertheless, a standard, and after passing, he is sure of a job at the highest wages paid to any of the engineering profession today.

There are many of these would-be engineers who would tackle the problem of running a locomotive or enter the engine-room of a steamship just as readily as they enter the stationary plant, and be it said, with just about the same or less measure of success, were it not for the "bugaboo" of the examination; they are afraid of it and with good reason. To illustrate: A few years ago I was running a locomotive on construction work, where no examination was required. The superintendent hired a man who said he was a locomotive man and put him to work. It was a "hill" road and the first trip this "engineer" let his train get beyond his control and it ran away and piled up at the bottom of the hill, luckily with no casualties. He was not dis-

charged and on the next trip, in spite of the fact that the engine was equipped with two injectors and a feed pump, all in good working order, he lost his water and burned the crown-sheet. *Some* "engineer," and the woods are full of them.

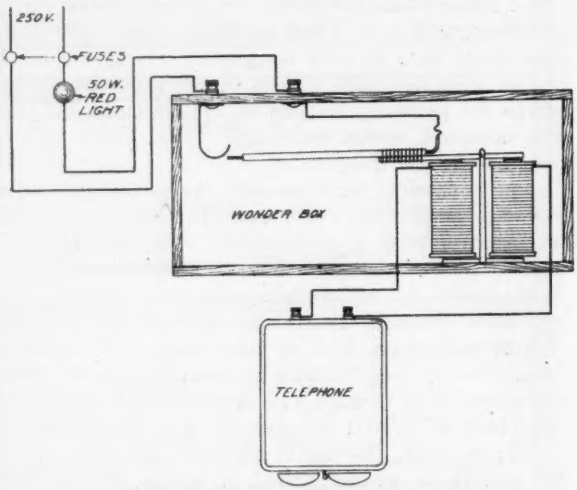
So, as Mr. Hannan says, it's high time for us to get busy. There is no conceivable reason why the stationary engineer should not have the same conditions as the marine and locomotive men do and if we do not help ourselves, nobody else will. Let us get together in some manner and *all* boost for a National License Law and at the same time see to it that the men who are to be the engineers of the future are required to serve as apprentices for the proper length of time. If we do this the rest will come pretty near taking care of itself and those men who are really competent engineers at the present time, will come into their own; so put your shoulder to the wheel and BOOST.

J. W. Eshnaur.

Telephone Signal

I am offering this idea as a possible help to anybody who may have telephones in noisy places and can't hear the bell. The device used in this instance is extremely simple and effective, and can be made up in any power plant at almost no cost.

This company is operating two power plants some distance apart and the chief engineer has the care of



SIGNAL DEVICE FOR TELEPHONE

both plants, as well as all the lights and water works in town and has a great deal of ground to cover every day. The local telephone system is a great help, but some of the phones are in noisy places and, as it was impossible to hear the bell, it was necessary to attract attention in some other way. So we went to work to get up something that would light a colored lamp when the phone rang, the colored lamp being placed in plain view of the attendant.

This rough sketch shows in detail the arrangements. The chief's first assistant named it the wonder box, and for want of a better name we let it go at that. A pair of old solenoids was found and a piece of stiff wire insulated from and bound to the lever, as shown, was placed in the wonder box and the wonder box connected in series with the colored lamp. The wonder box may be placed anywhere convenient and the solenoids connected to the terminals of the phone, and as the phone rings, the lever in the wonder box works up and down, making and breaking contact in the lamp line, causing the lamp to go on and off very rapidly. The spring may be shaped so that the connection will be made and not break until the attendant comes and breaks it. This has been a great help to us and as it can be made up in no time, some reader may decide to try it or something similar.

E. L. Ford.

The Club vs. Good Treatment

"Handle them with a club," said the chief engineer to the superintendent, when the question arose as to the best way to handle the men. The superintendent was a new man. The chief had been in charge only two months, and during this time there had been much complaining from the engineers and oilers. The chief also had his grievance. He felt that the superintendent, since the plant had not had one, was an unnecessary club every time a vacancy occurred, a man from the outside was considered. This gave the older engineers grounds for complaint; hence every new man put on had the old men against him.

The chief had used his club, and had mastered the situation seemingly; but the plant was losing money and the company saw fit to employ a general superintendent. This stirred up the hornet's nest again. The chief now joined the men to fight the new club. But the new club did not fall on anybody. The new club went about studying the plant from day to day. He had no bad language to give, nothing discouraging to offer.

At the end of two months, good treatment won out. The chief lost his popularity, and he moved on to the next place. A good will now prevails. The fuel bill has been reduced 35 per cent and other large savings made. Good treatment will win out every time.

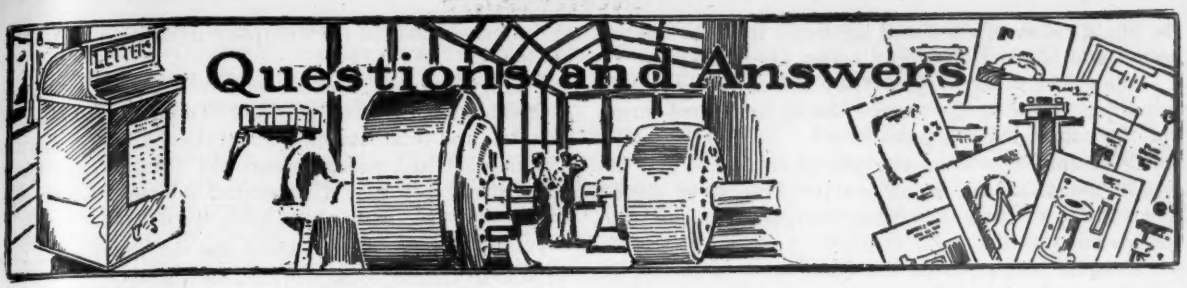
W. A. Darter.

Boiler Feed Pump Difficulties

If a feed pump is placed at any appreciable distance from the boilers fed and a number of elbows and other fittings are carried by the discharge line, considerable trouble due to a lack of sufficient water can frequently be overcome by substituting piping from ½ to 1 in. in excess of that called for by the pump discharge connection.

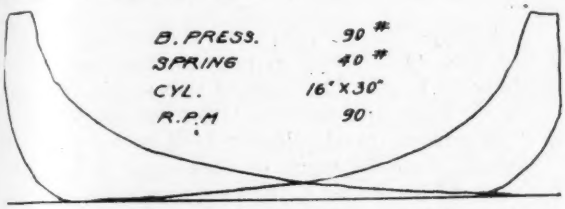
Another source of trouble frequently encountered is the location of the boiler feed pump relative to the feedwater heater. In many plants the pump is found placed on a level with the heater. This should not be done. A feed pump securing its supply from a heater placed at an elevation of from 6 to 8 ft. above the pump will not only handle the water more smoothly and economically but will be capable of handling it at a temperature of 210 deg. F. and even more. If operators would give this phase of their work closer attention they would find too that not only will their pumps work much more satisfactorily but the general upkeep will be considerably less. Where it has been customary to repack a pump once a month, let us say, they will find the packing to last at least twice as long and the general difficulties ordinarily encountered will be eliminated at least 50 per cent.

H. W. Rose.



Indicator Card For Criticism

THE INDICATOR CARD shown herewith was recently taken from a Wheelock engine having a piston diameter of 16 in., a stroke of 30 in. and operating at 90 r.p.m. when working under a steam pressure of 90 lb. gage. A 40-lb. spring was used.



WHAT IS WRONG WITH THIS CARD?

Does this card indicate anything wrong with the engine? If so, what? J. W. S.

Why This Emptying Reservoir

IN REFERENCE to the reservoir experience of R. A. F. as mentioned on page 652 of the July 15 issue, I am led to believe that there are two probable causes of his troubles. First, it is possible that the water was being drawn backward by his condensing system after he made the new pipe connections. Second, if that is not the cause, the trouble may be due to some siphoning connection in the line of a discharge pipe whereby, when the water reached a certain height, it would begin to overflow and not stop until all drawn out.

H. W. ROSE.

Withdrawing Ammonia Charge

I AM IN CHARGE of a Baker cooling (refrigerating) system. Will you kindly have your refrigerating expert inform me as to how I should proceed to take the ammonia out of the system and the receiving drum and return it to the charging drum? E. R.

When a charge of ammonia is to be withdrawn from a system, the first step is to see that the proper number of empty drums are ready. Do not use the drums in which ammonia has been received, but notify the manufacturers as to the number and size needed and empty drums for the purpose will be sent.

Estimate the number of pounds of ammonia in the system and allow 100 lb. for each 150-lb. capacity drum. Do not fill the drums more than two-thirds of their capacity.

Connect the empty drums to the suction side of the compressor and pull a vacuum of 20 in. Discharge the air to the atmosphere and not to the condenser.

Next pump all of the ammonia out of the low-pressure side of the system and into the condenser and liquid receiver.

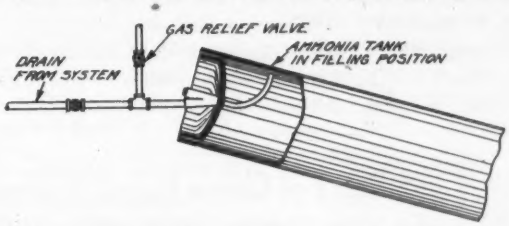
If the system is known to be tight, pump a vacuum of 20 in. on all the expansion coils or other type of evaporator. If there are any leaks, do not pump down below atmospheric pressure.

The compressor should be run slowly after the back pressure gage shows about 5 lb.

If the compressor is driven by a constant speed motor, the machine must be stopped and started several times, as the heating may become excessive and there is danger of explosion from ignition of the gasified oil and other impurities in the system.

Keep lots of cold water flowing over or through the condensers during the time the charge is being withdrawn. Purge the noncondensible gases from the condenser, if present.

Watch the gage glass on the liquid receiver and if the receiver fills and the condenser pressure goes high,



POSITION OF DRUM WHEN FILLING WITH AMMONIA

connect an empty drum and draw off till the liquid level shows in the glass. Do not empty the glass entirely till the last drum is being filled, as nothing but the solid liquid should be allowed to enter the drum.

When the condenser pressure drops back to normal, proceed with the pumping down.

After all the ammonia has been drawn out of the evaporating coils and a vacuum pumped, the main liquid and suction valves must be closed and examined to see that ammonia cannot leak back. It is a good plan to disconnect the lines and blank off any valves that show leakage.

Now that the entire charge of ammonia is in the condenser and liquid receiver, the noncondensible gases should be purged out. Then draw off as much liquid as can be put in the drums without lowering the level in the glass out of sight.

Next proceed to pump out the condenser coils one or two at a time, depending on the size of the plant; and as often as the glass on the receiver shows full, draw off into drums. In this way, at the last, only one coil of the condenser will be in use. When this point is reached, the machine is shut down and all valves, except those between the bottom of the one stand and

the liquid receiver, are closed tight and the lines disconnected and blanked off if any valves are leaking.

Allow cold water to flow freely through or over this last stand of condenser for at least ½ hr. Then purge out the noncondensible gases.

The empty drums must be placed on a scale and the weight noted. Place the drums just reverse or upside down to the position used when charging ammonia into the system.

The pipe leading from the drain valve of the liquid receiver to the drum should be ⅜-in. size and at least 5 ft. long, so as not to interfere with the correct operation of the scale. In this pipe and close to the drum a tee must be inserted and a nipple and valve be provided for a gas relief.

When filling a drum, open wide the valve on the drum and that in the drain line. Then open the drain valve at the liquid receiver just enough so that the liquid can be felt flowing through. Watch the scale beam and when the liquid ceases to enter the drum, close the valve on the drain line and open the gas relief for the small fraction of a minute. This allows the gas above the ammonia to escape. Then open the drain valve and more liquid will flow into the drum. The loss of ammonia through this gas relief valve is so small that it need not be considered.

The last stand of the condenser is emptied through the liquid receiver, the same as the others, only that it will take more time and attention, as the liquid will become gas bound often and the gas relief valve will have to be opened often.

The amount of ammonia that will be left in the system will scarcely cause a strong smell, for it will be nothing but a light gas.

A. G. Solomon.

Lead and Lap For Corliss Engine Valves

We have a triple-expansion Corliss engine equipped with three eccentrics, two single and one double. The cylinders are 24½, 36 and 54 in., respectively, in diameter and we ordinarily carry 24 in. of vacuum.

I should like to know how much lead and lap these valves should be given and after the valves are properly set to what degree should the eccentrics be advanced on the shaft? G. W. L.

A. For Corliss engines, the Allis-Chalmers Co. recommends the following valves for lap and lead:

Cylinder diameter, in.	Steam lap, in.	Exhaust lap, in.	Lead, in.
8 to 14	3/16	1/16	1/32
14 to 22	¼	⅛	1/32
22 to 32	5/16	3/16	3/64
32 to 36	⅜	¼	1/16

Although directions for valve setting are numerous, the following have some methods not commonly given and which are worth remembering:

First, remove the steam and exhaust bonnets and upon the end of the valve will be found a mark corresponding to the opening edge of the port. The direction of motion for opening the valve can be determined by working the wristplate by hand.

Second, examine the wristplate hub and bracket. Upon the bracket will be found a mark corresponding to the central position of the wristplate and two others locating the extreme travel of the wristplate in either direction of motion.

Third, see that the rocker arm travels an equal distance each side of the vertical position. To do this, loosen the eccentric and rotate it slowly about the shaft. Then, with a plumb bob and scale, measure the distance the rocker arm travels each side of its central position; adjust the length of the eccentric rod to bring the distances equal.

Fourth, rotate eccentric about the shaft and see if the wristplate travels equal distance each side of its central position, as shown by the travel marks. If it does not, adjust the length of the hook rod to bring them equal.

Fifth, block the wristplate in its central position, then pull up the dashpot rods until the hook pin engages with the steam hooks. Adjust the length of the steam and exhaust radius rods until the valves have the proper amount of lap as determined by the size and speed of engine.

Sixth, throw the wristplate with the starting bar first to one, then to the other extreme position, and adjust carefully the length of the dashpot rods so that the steam hooks will latch with the hook pins when the wristplate is at its extreme travel, allowing 1/32 in. for clearance.

Seventh, place the engine on dead center and see that the hook rod is fastened to the wristplate. The eccentric should then be turned in the direction the engine is to run until the proper amount of lead is secured, fasten the eccentric to the shaft and place the engine in the opposite dead center, and measure the lead. If it is not the same, make it so by adjusting the length of the steam radius rods.

Eighth, block the governor up half-way in the slot and fasten the reach rod levers at right angles to a line drawn half-way between the 2 rods. Adjust the length of the reach rods until the knockoff arm stands vertical; with the governor in this position, turn the engine over until the cutoff occurs, and measure carefully the distance the crosshead has traveled; place the engine so that it will be the same on the other side, and adjust the length of the reach rod until the cutoff will just occur. This insures equal cutoff at each end of the cylinder for these positions. See that the governor gag pot is perfectly adjusted, and that the pot is filled with light oil.

Ninth, drop the governor to its lowest position and see that safety chip on the knockoff lever is adjusted so as to prevent the steam hook from latching with the hook pin.

Tenth, tram your engine with a fine prick punch so as to be able to adjust it quickly in case of accident or in case it has been tampered with.

Maintaining Temperature For Drying

We have in our plant a large drying chamber which is heated with steam coils, the latter filling out the whole chamber, so arranged, that the cloth to be dried passes to and fro between the coils. At the present time, we are using live steam at 75 lb. pressure, which brings the heat to a maximum temperature of about 136 deg. F. Now we have installed a pipe line in connection with this drying chamber to make use of our exhaust steam from the engine which brings the temperature in the chamber to 100 deg. F.; as this is not enough to dry the cloth, we added a portion of live steam but found out that the live steam naturally overpowered the exhaust steam and instead of going into

the drier, preferred to go through the exhaust line into the atmosphere. Do you know of any way in which we can use our exhaust steam in connection with some live steam to bring the temperature to the desired degree?

F. M.

A. The only solution of your problem is to equalize the pressure of the exhaust steam and the live steam that comes to your drying coils. This will have to be done by putting in a relief valve on the outboard exhaust to the engine, set to maintain the desired pressure in the exhaust pipe, and this, of course, will put a back pressure on your engine.

The live steam line will have to be fitted with a reducing valve, set to cut down the pressure on the discharge side of the valve to that for which the relief valve is set.

From the temperature that you get in your drying chamber, evidently you have one of two conditions; either there is not sufficient exhaust steam to heat your chamber up to the required temperature, or else there is not sufficient heating surface in the coils. The temperature of the exhaust steam, at atmospheric pressure, would of course be 212 deg. F. The temperature of your live steam, at 75 lb. gage pressure, would be 320 deg. F.

From the fact that you get only 136 deg. F. with the live steam, I should suppose that the difficulty is in not having sufficient heating surface in the coils.

With your present equipment, just what proportion of live and exhaust steam you would need to keep the temperature in the chamber up to that necessary for the drying process, and what pressure you would have to establish by the use of relief valve and a reducing valve, would be a matter of experiment, which could be determined approximately by putting an ordinary stop valve into the atmospheric exhaust line of your engine, and closing this down until you maintained a pressure in the drying coils which would give you the temperature required. You could then get a relief valve and a reducing valve scheduled to maintain about this pressure, and these valves could be adjusted, after they were in position, for any slight difference which might be found necessary.

Distance Between Bridge Wall and Boiler Shell

WILL YOU please give me the rule to employ for determining the proper spacing between the top of the bridge wall and the shell of a boiler? C. B.

A. About the only guide for determining the distance between the top of the bridge wall to the boiler shell is the practice of having it of such a height as to provide an area over the bridge wall equal to 1/7 of the grate surface. This height commonly ranges at about 15 or 16 in. for average conditions.

According to this same rule for making the area of gas passages bear a certain ratio to the area of the grate surface, the flue area is 1/8 and the chimney area 1/9 of the grate area for average conditions with return tubular boilers.

Probable Cause of Leaky Tubes

I HAVE BEEN STUDYING T. H.'s letter in the July 1 issue, in regard to leaky boiler tubes, and I thought I would wait and see what was suggested. On page 700 of the Aug. 1 issue, W. G. Walters and H. W. Rose give suggestions to help T. H. overcome his trouble. In my opinion they have both overlooked the main feature of the trouble, *i.e.*, the latter part of the question.

T. H. says he has a 60-hp. boiler and a 30-hp. engine and two pumps. Assuming from this there is other equipment taking steam from the boiler, why should a 60-hp. boiler need forcing to supply a 30-hp. engine and two pumps? As a rule, small engines are large consumers of steam; allowing for that, suppose this engine is taking 50 lb. of steam per horsepower hour. The boiler should be able to supply this without any trouble. In the latter part of his question, he says that when he fills his boiler so full the water enters his pumps, and he also says that when his boiler is so filled, his engine continues to run full speed without knocking. From this statement, I believe he will find the cause of all his trouble at the engine. I would suggest that he examine his valve setting and he will probably find all the valve events late. This would be caused by eccentric slipping.

Taking all the events in their rotation, he may find the steam admission so late that the piston has reached the end of the stroke before cutoff takes place, expansion taking place on return stroke and exhaust closure not taking place until the piston had reached the end of its return stroke. Then the compression event will not occur until the piston is on the power stroke again. The same would apply to crank end of piston. This would allow the engine to run without knocking when pulling water; also, the steam consumption would be so heavy the boiler would be overloaded and need forcing to maintain the steam pressure. The water level is probably allowed to fluctuate, causing a varying temperature on the tube sheet with consequent contraction and expansion, causing the tubes to leak. L. CLARK.

Cooling Tower For Ice Plant Service

READING the letter of E. L. A. appearing on page 745 of the Aug. 15 issue, brings to mind some of the experiences which I have had in ice-making plants.

In one plant in particular, we took our water out of the ground with air at a pressure of about 60 to 65 lb. and carried it over the ammonia condenser, after which part of it was passed over the steam condensers and from there into an open feed water heater. That not used in connection with the steam condenser was re-boiled and delivered to a forecooler and then into ice cans for freezing. To prevent the formation of excessive scale, we used five pints of boiler compound and blew down our boilers every 8 hr. about 1½ gages each time. The blowing-down usually was done at 8 o'clock in the morning, in the afternoon at 4 o'clock and at midnight, after which we put the compound into the boilers. We washed out the boiler every three weeks and turbined the tubes, all of them, three times a year and I can say that we had but very little trouble with scale.

As to the use of a cooling tower for the prevention of scale, I do not think it will work unless the water contains considerable soft mud and it is planned to install a filtering trap in the cooling tower. Such an arrangement may undoubtedly clear the water of the mud; but as for the softening, I doubt very much whether a cooling tower will accomplish anything.

R. F. MUELLER.

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The Railroads

Plans for government ownership of the railroads are frequent in these days of change, and making of such plans seems to have become a popular indoor sport. The question is too serious to be treated in any such irresponsible spirit. Adequate transportation is at the foundation of prosperous industry. Out system cannot be played with by visionaries nor commandeered for class advantage without endangering our whole manufacturing and agricultural system.

On this subject, the statement of the Board of Directors of the Chamber of Commerce of the United States is so clear and sound that we reprint it in full, and commend it to the careful thought of readers.

If a false step is taken in the disposition of the railroads, it will almost certainly affect disastrously every business, every factory and every employe in the country. It is important that Congress be urged to act wisely and carefully, resisting the tendency to get rid of a difficult problem by choosing an easy course of action, and resisting likewise any coercion by organized bodies to act for the benefit of any class as against the benefit of the country as a whole, and all its people. The plans now being urged most strongly, do not, on analysis, give promise of the desired results.

"The demands of the railway labor organizations create a situation which calls for the most serious attention and deepest thought of all citizens. These demands raise vital questions which affect directly every phase of life throughout the United States. They constitute a definite program for government ownership and this despite the fact that government ownership has proved to be disastrous wherever it has been applied.

"Any proposal for government ownership of railroads, whatever the provision for operation, raises questions which every citizen must eventually consider for himself. To increase the present public debt from 30 to 50 billion dollars in order to acquire the roads would severely strain the credit of the nation and depress the value of the Liberty and Victory bonds held by millions of people. The public as a whole through the government would be asked to assume the burden and financial risks of railway capital, while the roads would be run by and for the managers and employes. The suggestion of possible reduction of costs of transportation and betterment of service under such a system is purely theoretical and has not been established in practice by the government operation of the railroads. On the contrary, in this country, as elsewhere, the very opposite results have been shown.

"Government ownership means a retarded development of the railroads. Because of the war the country is sadly behind hand in railroad construction. Additional facilities must be added at once and enormous railway extension must be made during the next few years to meet the actual demands of our country's growth. This calls for the highest type of individual initiative and enterprise. Politics must be kept out of the railroad business. To make the railroads public property and those who operate them government employes is to throw the railroads into the arena of party politics. In such an event there would be serious danger of autocratic control of the government by government employes.

"The overwhelming trend of public sentiment throughout the United States is opposed to government ownership of the railroads. The organizations constituting the membership of the Chamber of Commerce of the United States, scattered throughout all sections of our country, have just declared with practical unanimity in favor of adhering to the policy of corporate ownership and operation of the railroads under a comprehensive system of government regulation and with the return of the roads to their owners as soon as adequate legislation, such as the National Chamber asks, can be enacted.

"The Chamber of Commerce of the United States believes in the maintenance of that most vital principle of our American institution—private initiative.

"At its recent annual meeting in St. Louis it declared it to be essential that our government should scrupulously refrain from entering upon any of the fields of transportation, industry, commerce, or any phase of business that can be successfully undertaken and conducted by private enterprise.

"The concrete and actual question that confronts the country now is, shall we depart from these fundamental principles?

"Government ownership would monopolize and deaden, rather than democratize and revive, railroad transportation. It would paralyze a great industry whose vigorous development is essential to the happiness and prosperity of all our people."

Maintaining the Lighting System

Greater production and a higher degree of efficiency of the human element are the two most important weapons by means of which the individual can assist in combating the ever-increasing cost of every necessary commodity. And unless each and every one of us puts forth our greatest efforts along these lines, no amount of legislation or regulation can be of any permanent material benefit or even bring about a stabilized purchasing value of the dollar. Limitation of production and curtailed supply with growing demand is bound to bring about higher prices and hardship upon all. Demand cannot be lessened, but production can and must be increased.

Aside from the direct control the engineer has over the economical production of power he can also in the majority of cases exert his influence in other directions. One of these is the proper utilization of the illuminating system, not only within the power plant but also throughout the institution with which he is connected. If in direct charge of the mechanical and electrical equipment outside of that used for power-producing purposes his opportunities are practically unlimited, and while it may be impossible for him to make any decided changes for improvement in the general layout of the illuminating system there remains no doubt about his ability to improve working conditions for the other employes, and to increase production in general. This he can do by a study of conditions as they at present exist, and where needed by the adoption of more efficient lighting units and their proper location with reference to the work they serve employing an arrangement such as will insure a maximum degree of illumination, with minimum degree of eye strain upon the worker.

At present, except in those industries, which by their very nature require considerable artificial lighting, due either to long hours, or unfavorable local conditions, the illuminating system is practically out of use. With the coming of the fall days and their shortened hours of day light, the need of carefully going over the system becomes imperative, and it appears advisable that this work be done at the earliest possible moment. Where inefficient units are at present installed replace with improved types of lamps, making certain to employ only such reflecting units as will assist the workers toward realizing maximum production with a minimum degree of fatigue.

Frequently the design of the system is proper, but due to laxity on the part of those in charge of its maintenance the desired results have not been realized. The lighting and reflecting units have become dirt covered, thus greatly impairing their light-giving and reflecting properties, or as will occasionally be found, less efficient lamps have been used to replace the type and kind originally installed. In either case the remedy is simple and should at once be applied.

SCHOOLS of naval architecture and ship construction may soon become important branches of educational institutions of the United States if this nation continues its headway in maritime strength. Fourteen universities and technical colleges have signified their interest in a line of instruction that was decadent almost to the point of extinction when the needs of war presented a demand for ships that could not be denied, and some of them have already established courses in naval architecture, marine engineering and ship construction, while others are planning similar action.

The United States Shipping Board Emergency Fleet Corporation, which felt so keenly the lack of technicians in carrying out its shipbuilding program, and had to establish emergency schools for intensive training, is encouraging and fostering plans for the new schools in all institutions capable of expanding their fields of learning. It has furnished to those interested valuable data gained through experience with all phases of the shipbuilding industry in every quarter of the country, and stands ready to give similar aid to all who may apply.

INFORMATION secured by the American Manufacturers' Export Association indicates that the import restrictions imposed by Great Britain are intended only as a temporary measure.

England has determined to get back upon a normal basis, and has felt the necessity of giving her own people a chance to put their house in order before opening up her markets to the world. To do this, she will, for a certain period, put some of the goods manufactured in other countries on a restricted list, so that expanding the sale of those products in England will be, for the time being, impracticable.

It appears that within a year, at most, England will resume importation upon normal lines, and removal of restrictions may come within 6 mo.

New Type of Rotary Pump

THE principal thought involved in designing the recently developed rotary pump here illustrated was the elimination of such trouble as loss of prime, clogging, inadequate suction, short life. These pumps have now been in use for more than a year and have been found to possess the necessary qualities coupled with many other advantages. Their principal working

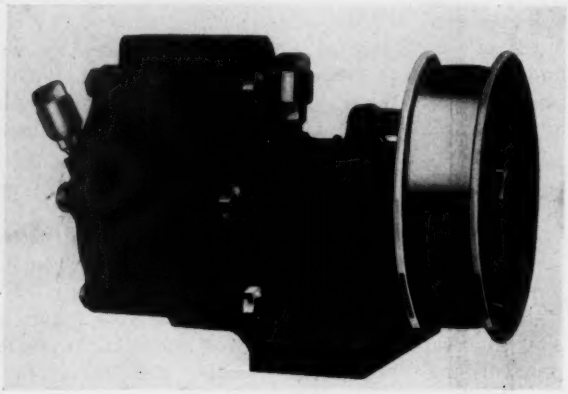


FIG. 1. EXTERIOR VIEW OF ROLLING TYPE ROTARY PUMP

parts consist of two rollers which rotate eccentrically in the pump chamber. The entire motion is rolling.

No relief valves or overflow piping are required. The outlet in the discharge piping may be closed and the pump allowed to run without damaging pump or piping. This result is obtained by use of a spring placed in the rectangular slot in the inner roller which bears against the squared shaft. This spring operates only when the pressure on the pump is as great as the pressure re-

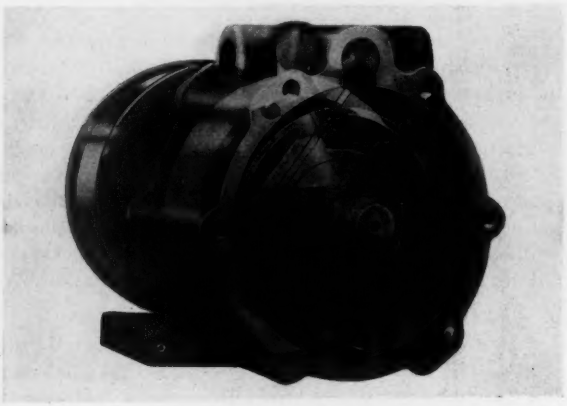


FIG. 2. INTERIOR OF NEW ROTARY PUMP

quired to compress the spring. When this pressure is reached, the compression of the spring allows the rollers to come to the center of the pump where they continue to revolve in the liquid without exerting further pressure on it. The fact that the spring operates only under this condition and one other described in the following paragraph assures long life to the spring.

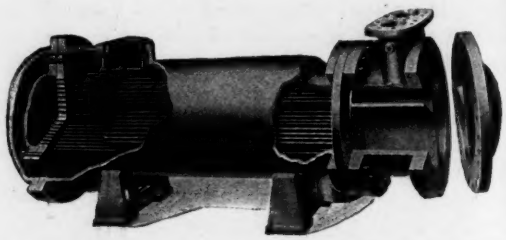
Foreign matter in the liquid does not affect the pump and will not clog it. Anything such as cast iron and steel chips, paper, rags, waste, etc., which can pass through the intake pipe will pass through the pump without clogging or damaging it in any way, because the action of the pump is to roll the liquid in front of the pump rotor. Should a chip stick, the spring described in the preceding paragraph will compress, allowing the roller to pass over the obstacle without damaging the pump and it will be washed out on the next revolution of the motor.

The pump may be used upside down or right side up and at any point on a machine where its application is most convenient. Either side of pump may be used as intake or outlet. Plain pumps may be used or reversing machine where no liquid is required when the machine is reversing. The pump can be reversed without harming it and it will deliver liquid again immediately its proper direction of rotation is resumed. A pump equipped with reverse valves will be furnished where it is necessary to maintain a constant flow in a given direction regardless of the direction of rotation of the pulley.

As far as efficient operation is concerned, speed is not a factor. It may be operated at speeds ranging from 100 to 600 r.p.m. or more, making it applicable to all types of machines without extra expense of making special provision for either high or low speeds in order to secure maximum efficiency. The fact that the pump may be operated at very low speeds, however, insures long life and where this low speed can be obtained advantage can be taken of this feature.

Instantaneous Water Heater

ON general principles, the heater shown herewith is based upon the design of an old, successful type; but many changes in details have been made, bringing it up to date in every respect and greatly increasing its efficiency. Because of its ability to transfer heat rapidly it is known as an instantaneous heater.



INSTANTANEOUS WATER HEATER WITH MANY NEW FEATURES OF DESIGN

The shell of the heater is of close grain cast iron, tube plates of rolled steel, and tubes of ⅝-in. seamless drawn brass tubing, expanding into a fixed tube plate at one end and into a floating head at the other end. This floating construction permits of expansion and contraction of the tubes without strain on the tube joints. The live or exhaust steam is admitted to the shell where it gives up its heat and the condensate is drained off through the connection at the bottom. The water to be heated passes through the tubes, which are arranged in 2, 4, 6 or 8 passes. The steam lanes have been carefully planned to distribute the steam uniformly over the tubes and in every respect this new design conforms to modern practice.

The World's Largest Steam Turbine

This new unit, the purpose of which is to assist in meeting the greatly increased demand for transportation in New York City, occupies a floor space of 52 by 50 ft., and is about 19 ft. high. The high-pressure element receives steam at 205 lb. gage pressure, superheated 150 deg. F., and exhausts it into the low-pressure elements at 15 lb. gage pressure. The two low-pressure elements are identical in construction, and each receives one-half of the steam from the high-pressure element and exhausts it into the condenser where a 29-in. vacuum is maintained. All three elements operate at 1500 r.p.m., and each drives a generator rated at 20,000 kw. continuously (23,500 kw. for 2 hr., and 30,000 kw. for a half hour). The generators deliver three-phase, 25-cycle, 11,000-v. alternating current.

The Turbines

Though consisting of three separate elements, the entire machine is started, synchronized, and controlled

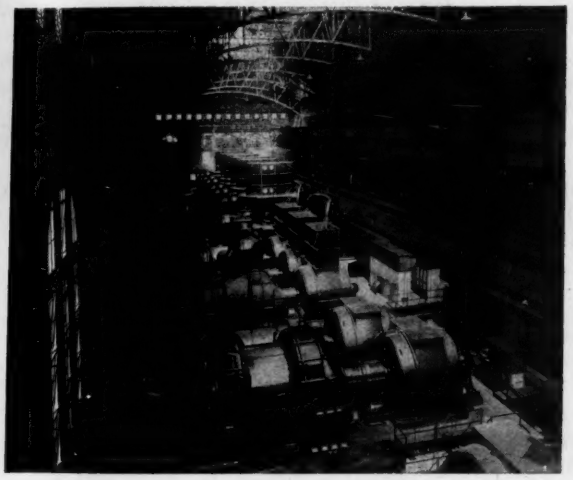


FIG. 1. INTERIOR VIEW OF EAST 74TH ST. STATION INTERBOROUGH RAPID TRANSIT CO., SHOWING 30,000-KW. UNIT IN FOREGROUND, 70,000-KW. TRIPLE COMPOUND UNIT IN CENTER AND OLD 7500-HP. ENGINE SET IN REAR

as a single unit. At the same time, any one or two of the elements can be shut down without interfering with the remainder, so that the high efficiency of a single large machine is combined with the flexibility of three smaller ones. In addition, the three small elements are mechanically much stronger than a single large one; the temperature differences in any cylinder are considerably less, and commercially common materials, with moderate blade speeds and stresses, can be used.

All of the turbines are of the pure reaction type, without the usual impulse elements, as this construction is considered preferable in view of the great volumes of steam to be handled. The high-pressure turbine is of the single-flow type, and is made of cast steel. The low-pressure turbines are of the semi-double-flow type; that is, the steam enters near the center of the turbine and flows as a whole through a portion of the blading, and then divides into two portions, each of which flows through a separate section into the condenser. Since the low-pressure turbines must receive high-pressure steam in case the high-pressure turbine is shut down, the central portions of these turbines are made of cast steel also. All three rotors are equipped with Kingsbury thrust bearings, to prevent axial movement.

The Governor

The governing mechanism must not only control the unit as a whole, but also each turbine operating separately.

Some of the operations performed by the governors are as follows:

If serious electrical trouble develops on the circuit of one of the generators of the low-pressure turbines, a circuit breaker will disconnect this machine from the bus bars. Relieved of load, the turbine begins to speed up; but before its speed has increased 4 per cent, its governor shuts off the steam supply from the high-pressure turbine. This, of course, raises the back pressure of the high pressure unit, and a back-pressure valve opens, allowing part of the exhaust from the high-pressure turbine to pass into the atmosphere. The remainder goes into the other low-pressure turbine. In the meantime, the first low-pressure turbine, being without steam, shuts down. When its speed reaches 3 per cent below normal, the governor admits high-pressure steam, and the turbine continues to operate at this speed until the switchboard operator either shuts it down or restores normal conditions.

Each turbine also has an emergency stop, which will operate automatically in case the governor fails and the turbine begins to race, or it can be tripped by the switchboard operator.

When one of the turbines fails with the entire unit heavily loaded, the governors permit each of the remaining turbines to carry the maximum load of 30,000 kw. This can be maintained for a half hour, which is regarded as sufficient time to get other generators into operation, and thus relieve the overloaded turbine.

Condensers

This equipment consists of two 25,000-sq. ft. surface condensers for each low-pressure turbine. There are four circulating pumps, three Le Blanc air pumps, and four condensate pumps. All of these are turbine-driven (the air pumps directly and the others through gears), and all are so arranged that one or more can be put out of service without interfering with the operation of the condenser.

Performance

The steam consumption of the entire unit at its point of best efficiency is 10.7 lb. per kilowatt-hour. The pressure turbine and one low-pressure turbine, operating together, consume 12 lb. of steam per kilowatt-hour; and one low-pressure turbine alone consumes 14.25 lb. The total steam consumption at full load is 826,000 lb. per hour.

One of the quickest and cheapest methods of adding to the strength of a wooden box is to wrap it with thin, flat metal straps.

News Notes

THE CHICAGO PNEUMATIC TOOL CO. announces the appointment of J. L. Canby as District Manager of Sales at Chicago, succeeding Nelson B. Gatch, who has been transferred to New York as District Manager of Sales.

GREEN ENGINEERING CO. announces the appointment of the firm of Bull & Livensparger as sales representatives in Chicago and northern Illinois territory. They took charge of the Chicago sales office, 14 E. Jackson Bl., Aug. 1. E. H. Bull has been connected with the company as an engineer for the past 7 yr., and D. A. Livensparger has been a member of the sales force for the past 9 yr.

C. LINCOLN SMITH, who, in the past, has been Sales Engineer for the Sanford Riley Stoker Co. and the Murphy Iron Works in the Chicago territory, has been transferred to the Pittsburgh office. On and after Aug. 15, Mr. Smith will act as District Manager, looking after the sales and service for both the Riley Underfeed Stoker and the Murphy Automatic Furnace in the Pittsburgh district.

ANNOUNCEMENT IS made that Dwight P. Robinson & Co., Inc., New York, has been awarded a contract by the Duquesne Lighting Co., of Pittsburgh, to design and construct a power station at Cheswick, near Pittsburgh, to have an ultimate capacity of 300,000 kw., of which one unit of 60,000 kw. is to be installed initially. The work consists of a new power station building with the necessary complement of boilers, piping, electrical apparatus, coal handling devices, coal storage, etc. It is anticipated that the work of installing the first unit will require about 12 mo.

POWDERED COAL IS to be used throughout for firing boilers and furnaces in the new sheet mill of the Falcon Steel Co. now being erected at Niles, Ohio.

The power plant boilers will be powdered coal fired using compressed air system for transporting and burning the coal. The pulverized coal will be transported from the milling plant through standard 4-in. diameter wrought pipes to furnaces and boilers for various distances aggregating approximately 800 ft., and will be switched from the main distribution line to a storage bin in the power house for use as required for the boilers.

STEPS were taken recently by the Van Wie Pump Co., which sold its plant at Nos. 709-23 West Fayette St., Syracuse, N. Y., to the United States Hoffman Co., to acquire a site for a new factory which will give employment to 100 molders, pattern makers and machinists. It is purposed to have this plant ready for operation late in the fall.

The Van Wie Pump Works is the oldest centrifugal pump works in North America, having been established at Baldwinsville in 1860. The business was brought to Syracuse in 1880 and for 30 yr. was operated by Irving Van Wie and passed into the hands of the present management in 1905. Stephen Bastable is president of the company and George W. O'Brien treasurer. In the new plant the company will have increased facilities and will increase the output of pumps.

"WHAT WORRIED Admiral Jellico Most" is the title of a booklet being distributed by the Wheeler Condenser & Engineering Co., of Carteret, N. J.

THE FATE-ROOT-HEATH CO. has just placed an order for a gas producer with The Smith Gas Engineering Co., to replace natural gas for power purposes.

GEORGE B. ALLAN, Texas representative of the Yarnall-Waring Co., Philadelphia, who has been located at 305 Southern Pacific Building, Houston, will hereafter make his headquarters in Dallas.

TECHNICAL PAPER 217, Saving Coal in Steam Power Plants, by U. S. Fuel Administration, was recently published and may be obtained by addressing the Director of the Bureau of Mines, Washington, D. C.

THE GOULDS MANUFACTURING CO. of Seneca Falls, manufacturers of pumps for every service, will open, on Sept. 1, a district sales office in Detroit, Mich. This office will be located in the Dime Bank Building, and will be in charge of E. B. Gould, who has recently returned after 18 mo. service in France.

THE DIRECTOR OF SALES announces that the War Department is preparing to offer for sale under sealed proposals several thousand gallons of "Vatudrip," a liquid used for preventing rust on various metal products. It is put up in cans and the bulk of it is stored at Indianapolis, Ind. Information regarding the disposal of this product can be obtained from the Committee on Sale of Materials, Ordnance Department, 6th and B. Sts., S. W., Washington, D. C.

U S. CIVIL SERVICE COMMISSION announces examinations as follows: Engineer, $3000 or over a year; Assistant Engineer, $1800-$2880; Junior Engineer, $1200-1740; Engineering Draftsman, $1200-$3000; Junior Electrical Engineer, $1080-$1200. Competitors will not be required to report for examination at any place, but will be rated on physical ability, education and experience. Applications will be received until further notice.

THE UPSET POSITION of the coal mining industry in Great Britain these days has given rise to much discussion as to American methods of production and even the possibility of American coal being brought into the British market. The question has even got into Parliament, according to the American Chamber of Commerce in London.

The American Chamber reports that in reply to a question put in the House of Commons, the Secretary of the Board of Trade said he understood that it was a fact that contracts have been made for American coal for delivery to European ports; but that the cost of American coal delivered in European ports is at the present time higher than the corresponding price for British coal, owing to the higher rates of freight from America. There was no restriction on the importation of coal into Great Britain; but according to the statement, American coal can only be delivered in Great Britain at very much higher prices than that at which British coal is now obtainable.

GET THE thrift habit and get out of debt. Thrift Stamps and W. S. S. are first aids.